The

American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

Arthur L. Schipper, *Editor*

CONTENTS

Plants of Iron Mountain, Rogue River Range, Oregon ..... William H. Baker 1

A Distributional Study of the Epiphytic Plants of the Olympic Peninsula, Washington ..... Babette Brown Coleman, Walter C. Muenscher, and Donald R. Charles 54

A Qualitative and Quantitative Study of the Plankton Algae in Southwestern Georgia ..... George J. Schumacher 88

Florida Scytonemataceae. II ..... C. S. Nielsen and Grace C. Madsen 116

The Mass Culture of a Presumably Autotrophic Dinoflagellate ..... M. J. Delany 126

The Hooks of Taenioid Cestodes from North American Felids ..... Nathan W. Riser 133

Observations on the Life Histories and the Distribution of the Xanthidae (Mud Crabs) of Chesapeake Bay ..... Edward Parsons Ryan 138

A New Crayfish of the Genus Orconectes from Illinois (Decapoda, Astacidae) ..... Paul L. Brown 163

The Ants of Ramsey County, North Dakota ..... Paul B. Kannowski 168

Parasitic and Nonparasitic Arthropods from Bat Caves in Texas and Mexico ..... Raymond E. Ryckman 186

Redescriptions of Four Water-Mites of the Genus Aturus ..... Rodger Mitchell 191

The Mussel Population of an Area of Loamy-Sand Bottom of Lake Texoma ..... Carl D. Riggs and Glenn R. Webb 197

A Comparative Study of the Cephalic Lateral-Line System of North American Cyprinidae ..... Helen J. Illick 204

Factors Influencing Size and Composition of Populations of Rana Clamitans ..... Bernard Martof 224

Molt of the Short-tailed Shrew, Blarina Brevicauda ..... James S. Findley and J. Knox Jones, Jr. 246

Bones of Mammals from West Virginia Caves ..... Charles O. Handley, Jr. 250

Vol. 56 July, 1956 No. 1

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Plants of Iron Mountain, Rogue River Range, Oregon[1]

William H. Baker

University of Idaho, Moscow

Iron Mountain is located in the Rogue River Range, on the Coquille-Rogue River Divide in Coos-Curry Counties (fig. 1). The mountain is 15 air miles from the Pacific Ocean and is directly east of Port Orford, Oregon. It is 10 miles north of the Rogue River and is the highest peak in the area, reaching an elevation of 4,000 feet.

PHYSIOGRAPHY AND TOPOGRAPHY

The steep terrain of the north slope plunges into Sucker Creek Canyon and Copper Mountain Canyon which angle toward each other to form fairly

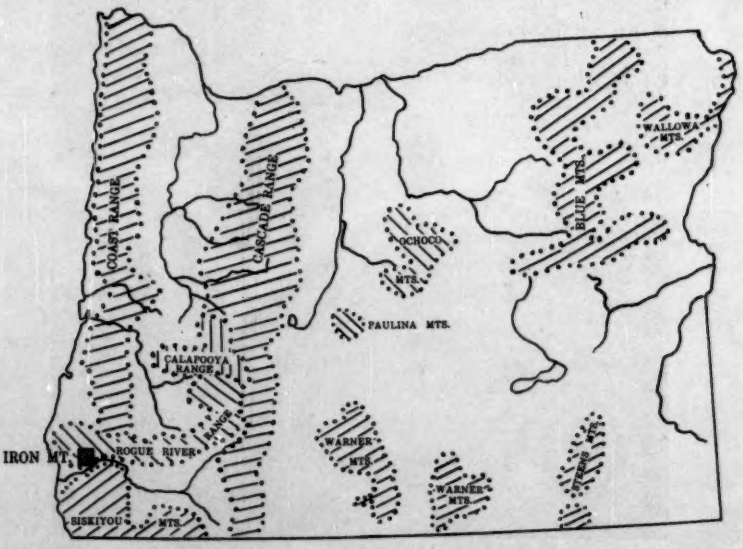

Fig. 1.—Map of Oregon; showing location of Iron Mountain and the Rogue River Range in relation to the other mountain ranges in the state.

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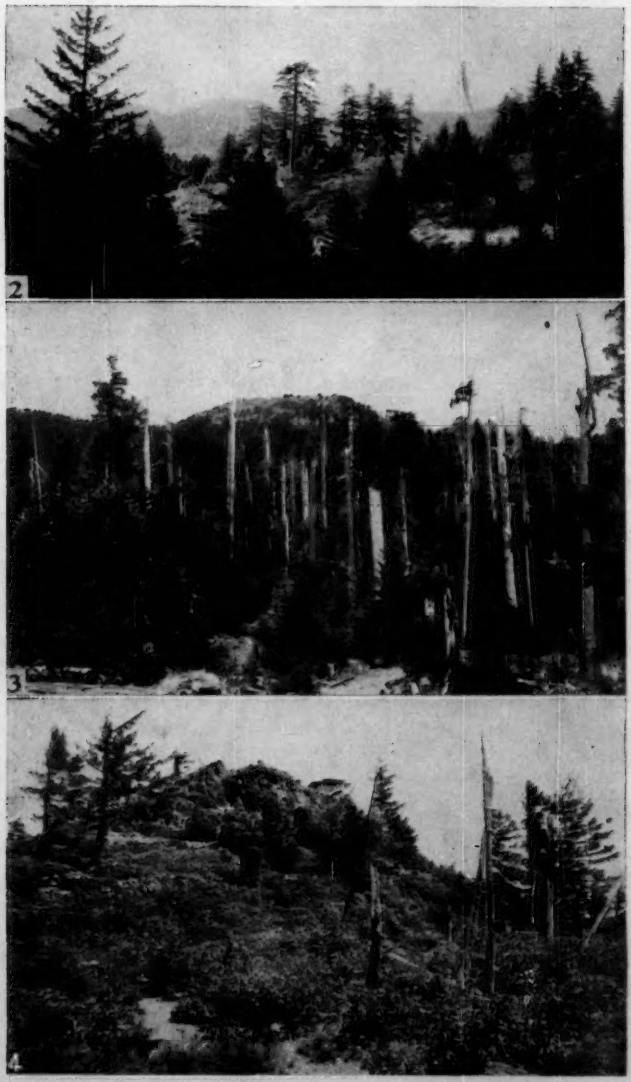


Figs. 2-4.—2. General View of Iron Mountain from the Middle Elk Road, Coquille Rogue River Divide; showing the east face in the distance. 3. East slope of Iron Mountain from Smith Claim; Port Orford cedar snags in foreground. 4. Looking toward the summit of Iron Mountain from the south saddle; low shrubs form the chaparral growth on the upper slopes.

natural boundaries in this direction. Along the south and southwest slopes the limits are plainly indicated by Bonanza Basin and McCurdy Camp, while the southeast and east slopes are bounded by the base of Ophir Mountain and the watershed formed by the South Fork of Rock Creek. The south slope is drained by Boulder Creek and Foster Creek, the east slope by the North and South Fork of Rock Creek, the north slope by Sucker Creek and the South Fork of Elk River, and the west slope by Lobster Creek and its tributaries (figs. 2-8).

The geologic formations are great intrusive masses of granitic rocks bordered by metamorphics: slates, serpentines and marbles, with some older lavas, generally referred to as greenstones. In general they are Paleozoic and Mesozoic in age. In addition there are many basic intrusive masses of such rocks as peridotites. The topography of the region is broken and rugged, due to excessive dissection and the nature of the formations which are apparently old and heavily metamorphosed. The whole pattern is a maze of ridges and valleys giving a very confusing topographic picture (Smith, 1940).

CLIMATE

Iron Mountain is situated in a region which has a marine climate, a relatively high winter precipitation in the form of rain or snow, a high summer temperature, fairly moderate winter temperature, low summer precipitation, and a long growing season.

The nearest weather stations are located at Port Orford and Gold Beach on the Pacific Ocean. There are no weather records available for Iron Mountain.

The prevailing winds are westerly, blowing inland from the ocean. The annual rainfall of the area is approximately 70 inches, but may be higher on Iron Mountain because of higher altitudes. Most of the rainfall occurs from October to May. The summer precipitation during the three months of June, July, and August is only 3 inches.

The growing season is comparatively long, ranging from 238 days at Gold Beach to 286 days at Port Orford. It is estimated that Iron Mountain has a growing season from 160 to 180 days.

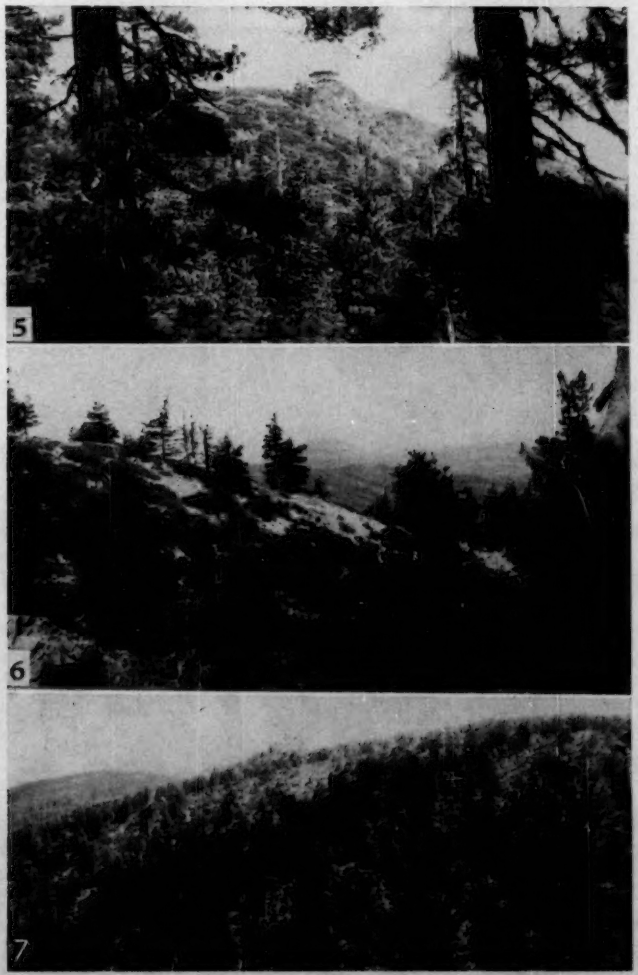
The snowfall during the winter months is usually quite heavy and some years deep drifts are present until the middle of June.

LIFE ZONES

On Iron Mountain only the Canadian and Transition Zones are represented since the summit is only 4,000 feet in elevation. A few plants grow here that inhabit the Hudsonian Zone in the Cascades, e.g., *Penstemon rupicola, Lomatium martindalei, Phleum alpinum,* etc. This is mentioned to show that the boundaries of life zones are not level altitudinal lines. It is not unusual for some species to grow from near sea level to timber line.

The Canadian Zone extends from about 3,000 to 4,000 feet on Iron Mountain. There is no sharp line of division between it and the Transition Zone. Over half of the plants represented here grow in both the Canadian and Transition Zones. The Canadian is the least well defined of all the life zones, and its recognition is dependent on the presence of certain indicator

plants, *Pinus monticola, P. contorta, Juniperus communis* var. *montana, Clintonia uniflora, Xerophyllum tenax, Anemone deltoidea* and *Acer glabrum* being the most important. The presence of any one of these species in an area might not be very significant, but when they all occur, it is a very good indication of the Canadian Zone. The following species are found principally or



Figs. 5-7.—5. A view of the lookout and summit from the east face, the trees are Western white pine. 6. Southwest slope of Iron Mountain showing characteristic chaparral type growth and scattered trees. 7. West slope taken from the south side of Iron Mountain, summit and lookout in the center of the picture. Typical forested slope with brushy openings.

wholly in the Canadian Zone and could be considered indicators of this Zone on Iron Mountain:

Polypodium hesperium, Cheilanthes gracillima, C. siliquosa, Cryptogramma acrostichoides, Pinus monticola, P. contorta, Picea breweriana, Juniperus communis var. *montana, Melica geyeri, Phleum alpinum, Hierochloe occidentalis, Scirpus criniger, Lysichitum, americanum, Juncus effusus, Narthecium californicum, Xerophyllum tenax, Zigadenus fremontii, Tofieldia occidentalis, Lilium parvum, Clintonia uniflora, Disporum hookeri, Streptopus amplexifolius, Horkelia sericata, Sisyrinchium sarmentosum, Cypripedium californicum, Habenaria sparsiflora, H. unalascensis, Listera caurina, Corallorhiza striata, Calypso bulbosa, Quercus sadleriana, Q. vaccinifolia, Montia flagellaris, Arenaria nuttallii* var. *gregaria, A. macrophylla, Silene campanulata, Anemone deltoidea, A. adamsiana, Coptis laciniata, Sedum laxum, Saxifraga mertensiana, Tiarella unifoliata, Amelanchier pallida, Trientalis arctica, Lotus oblongifolius* var. *torreyi, Acer glabrum, Ceanothus pumilus, Viola glabella, V. cuneata, Lomatium macrocarpum, L. martindalei, Garrya buxifolia, Chimaphila umbellata* var. *occidentalis, C. menziesii, Pyrola secunda, P. aphylla, P. bracteata, P. dentata, P. picta, Hypopitys lanuginosa, H. fimbriata, Allotropa virgata, Pterospora andromedea, Hemitomes congestum, Pleuricospora fimbriolata, Gaultheria ovatifolia, Arctostaphylos nevadensis, Vaccinium membranaceum, Gentiana sceptrum, Phlox diffusa* var. *longistylis, Penstemon rupicola, P. rattanii, Valeriana sitchensis, Hieracium cynoglossoides, Antennaria suffrutescens, A. rosea, Rudbeckia californica, Luina hypoleuca, Arnica parviflora, A. cernua,* and *Senecio canus.*

The Humid and Arid Transition Zones are both represented at elevations generally below 3,000 feet. The most characteristic tree of the Humid Transition is *Pseudotsuga taxifolia* but *Tsuga heterophylla* is also present. The tree best representing the Arid Transition Zone is *Libocedrus decurrens. Pinus ponderosa* and *P. jeffreyi* are also both present in this Zone. The following plants are representative of the Transition Zone on the mountain:

Polystichum munitum, Pseudotsuga taxifolia, Libocedrus decurrens, Chamaecyparis lawsoniana, Festuca megalura, Agrostis exarata, Carex exsiccata, C. obnupta, Juncus bufonius, Calochortus tolmiei, Smilacina racemosa, Disporum smithii, Montia sibirica, Ranunculus occidentalis, Berberis nervosa, Mitella ovalis, Heuchera micrantha, Tellima grandiflora, Tiarella trifoliata, Whipplea modesta, Lotus micranthus, Viola sempervirens, Epilobium adenocaulon, Aralia californica, Perideridia oregana, Angelica arguta, Rhododendron occidentale, Gaultheria shallon, Arbutus menziesii, Phacelia corymbosa, Trichostema

Fig. 8.—West slope of Iron Mountain from Middle Elk Road near McCurdy Camp junction. The density of the forest in the draws is apparent.

lanceolatum, Mimulus moschatus, Veronica americana, Lonicera hispidula, Madia madioides, Petasites speciosa, Arnica cordifolia, Collomia heterophylla, Arctostaphylos columbiana, Convolvulus polymorphus, Satureja douglasii, Galium triflorum, G. bolanderi, Campanula prenanthoides, Sambucus coerulea, and *Gnaphalium microcephalum* var. *thermale.*

A chaparral belt extends along a wide area on the east and south slopes. This begins in the Transition Zone but extends upward into the Canadian on the south slope. Some of the area about the summit is also covered with brush. Sometimes scattered and occasional trees are present such as *Pinus monticola, P. lambertiana, P. ponderosa, and P. attenuata* (on ridges). The principal shrubs on these brushy hillsides include:

Juniperus communis var. *montana, Arctostaphylos patula, A. columbiana, A. nevadensis, A. hispidula, A. canescens, Quercus sadleriana, Q. vaccinifolia, Castanopsis chrysophylla, Lithocarpus densiflorus* (shrub), *Ceanothus velutinus, C. pumilus, Rhamnus californica* var. *occidentalis, Garrya buxifolia,* and *Umbellularia californica* (shrubby form).

THE FLORAL ELEMENTS

The plants of the area are made up for the most part of species coming from two different floral provinces, — the Alaskan or Northern element which extends southward along the chain of coastal mountains, and the Californian or Southern element which extends northward from California. Another small but interesting segment of the flora is made up of the narrow endemics which make up a moderately high percentage of the plants of the region.

The Northern element includes many species that are common on Iron Mountain and grow principally northward to Alaska. Nine species reach their southern limit in our region or are not known at the present time to occur beyond northern California. The list of these species follows:

Erythronium oregonum, Montia flagellaris, Angelica arguta, Ligusticum apiifolium, Pyrola bracteata, Hypopitys lanuginosa, Gaultheria ovatifolia, Trientalis arctica, and *Phlox diffusa* var. *longistylis.*

The Southern element is by far the most important and largest element in the flora of Iron Mountain. The plants of this element are at present more widely distributed to the south of our area and appear to be predominantly of Californian origin. The Rogue River, situated 10 miles south of the region, forms an effective barrier to the plants of the Southern element. Jepson (1925) makes the following statement,

> Of the various features which distinguish the northern margins of the California province, the Rogue River is one of greatest importance as defining by a mainly physiological barrier the botanical boundary of the California province northward. There are a large number of species of Washington and Oregon which extend south to, or nearly to, the Rogue River, while a large number of species of California extend north to, or nearly to, the Rogue River. A number of species, to be sure, cross the Rogue but extend northward only a short distance. Similarly a number of Oregon species cross the Rogue but extend southward only a limited distance. The Rogue, in addition, therefore, as to such species, represents a mean of the physical conditions in a transition area.

The 60 species listed below are plants that either reach their known northern limit on Iron Mountain or, for the most part, do not extend any great distance beyond the mountain. This list consists of 20% of the total flora of Iron Mountain:

Festuca californica, Scirpus criniger, Carex mendocinencis, Narthecium californicum, Zigadenus fremontii, Veratrum insolitum, Lilium parvum, L. pardalinum, Disporum hookeri, Sedum laxum, Whipplea modesta, Ribes glutinosum, R. cruentum, Amelanchier pallida, Holodiscus discolor var. *delnortensis, Lotus crassifolius, L. oblongifolius, Trillium*

rivale, Cypripedium californicum, Quercus chrysolepis, Q. sadleriana, Q. vaccinifolia, Lithocarpus densiflorus, Arenaria nuttallii var. *gregaria, Silene campanulata, Anemone adamsiana, Berberis piperiana, Vancouveria planipetala, Umbellularia californica, Streptanthus tortuosus* var. *oblongus, Erysimum concinnum, Dentaria californica, Chrysamphora californica, Monardella villosa, Synthyris reniformis* var. *cordata, Penstemon rattanii, Castilleja pruinosa, Boschniakia hookeri, Galium bolanderi, Campanula prenanthoides, Hieracium bolanderi, Vicia californica, Lathyrus vestitus, Polygala californica, Sidalcea malvaeflora, Aralia californica, Perideridia oregana, Garrya buxifolia, Hypopitys fimbriata, Rhododendron occidentale, Arctostaphylos canescens, Gentiana sceptrum, Convolvulus polymorphus, Phacelia corymbosa, Erigeron foliosus* var. *confinis, Antennaria suffrutescens, Rudbeckia californica, Arnica parviflora, A. spathulata, Senecio bolanderi,* and *S. canus.*

Endemic species can be divided into two groups — broad endemics with a rather wide distribution within a local area or narrow endemics with a very limited range often confined to a single station or to several associated stations. Narrow endemics can be divided into those which have evolved in the region within recent times and have not had the opportunity to have become widespread, and relict species, plants which are remnants of a former vegetation which have persisted in the local area for a long time. Approximately 4% of the flora of Iron Mountain is made up of endemics. Most of these species are probably relicts because the area is one of considerable geologic age. It would seem that they would have had ample time to spread. However, unusual climatic and physiographic factors, which are present here, may also have important effects on endemism. The following species occur, sometimes known from only a few stations or covering a very limited area in extent:

Picea breweriana, Iris innominata, Sedum laxum, Saxifraga howellii, Horkelia sericata, Rhamnus californica var. *occidentalis, Ceanothus pumilus, Arctostaphylos hispidula, Arnica cernua, A. spathulata, Cirsium acanthodontum, Quercus sadleriana* and *Phacelia corymbosa.*

Introduced Species

The introduced species consist of 10% of the total flora on Iron Mountain. This compares very favorably with the percent of introduced species in the state. It was found that the adventive species in the state of Oregon approximate 10% also. This estimate is based on those species listed as introduced by Peck (1941).

Twenty-nine species were collected, of which a large proportion were found at Smith Claim Cabins, growing in and about the yard. The influence of a human habitation of this sort is very great. All the adventive species are of European origin. Only 9 are monocotyledons and all of these are grasses. The two largest families present are Compositae and Cruciferae, each with 5 species represented. On the basis of duration, 55% are perennials and 45% are annuals. A list of these species follows:

Bromus tectorum, B. mollis, Dactylis glomerata, Lolium perenne, Aira caryophyllea, Holcus lanatus, Agrostis tenuis, Capsella bursa-pastoris, Polypogon monspeliensis, Anthoxanthum odoratum, Rumex acetosella, R. conglomeratus, R. obtusifolius, Spergularia rubra, Lepidium perfoliatum, Camelina microcarpa, Brassica campestris, Erysimum repandum, Rubus laciniatus, Hypericum perforatum, Prunella vulgaris, Verbascum blattaria, Plantago lanceolata, P. major, Hypochaeris radicata, Chrysanthemum leucanthemum, Senecio vulgaris, S. sylvaticus and *Cirsium vulgare.*

Extensions in Range

Plants on Iron Mountain which are considered new distributional records comprise a total of 41 species. This equals 14% of the plants collected on the

mountain. The relatively high percentage is very likely due to the considerable number of California plants which extend for only a short distance across the Rogue. The mountain had not been collected previously and many of the plants had, heretofore, been known only as far north as the south side of the Rogue River. It has been demonstrated that many of these species cross the Rogue and grow on the north side of the Rogue River as well. This does not in any way impair the importance of the Rogue River as a physiological barrier. Of the plants which are recorded as range extensions, 85% are from the Southern element.

Several species, i.e., *Penstemon rupicola*, *Vaccinium membranaceum* and *Antennaria rosea*, which are not known to occur in the Coast Range, grow on Iron Mountain. These plants are fairly common in the Cascade Mountains. This is considered of interest because a number of Cascade range plants which are absent from the Coast Range appear again in the Siskiyous of Southern Oregon. *Penstemon rupicola* is found on several coastal peaks south of Iron Mountain. The writer has collected it also on Snow Camp Mountain in central Curry County. It is not known to occur in California. It has been previously mentioned that the plants of Iron Mountain are, for the most part, from the north or the south. There are only a few plants that may have migrated to our region from the Cascades and eastward.

Each plant in the following list is designated by a letter symbol suggesting probable origin of the species. (N) signifies the Northern or Alaskan element; (S) the Southern or California element; (E) the Eastern element:

Picea breweriana (S), *Scirpus criniger* (S), *Narthecium californicum* (S), *Trillium rivale* (S), *Iris innominata* (S), *Quercus sadleriana* (S), *Q. vaccinifolia* (S), *Arenaria nuttallii* var. *gregaria* (S), *Anemone adamsiana* (S), *Berberis piperiana* (S), *Vancouveria planipetala* (S), *Dentaria californica* (S), *Streptanthus tortuosis* var. *oblongus* (S), *Sedum laxum* (S), *Saxifraga howellii* (S), *Amelanchier pallida* (S), *Holodiscus discolor* var. *delnortensis* (S), *Polygala californica* (S), *Horkelia sericata* (S), *Lathyrus vestitus* (S), *Acer glabrum* (E), *Rhamnus californica* var. *occidentalis* (S), *Ceanothus pumilus* (S), *Sidalcea malvaeflora* (S), *Viola cuneata* (S), *Garrya buxifolia* (S), *Arctostaphylos hispidula* (S), *Vaccinium membranaceum* (E), *Gentiana sceptrum* (S), *Convolvulus polymorphus* (S), *Phlox diffusa* var. *longistylis* (N), *Phacelia corymbosa* (S), *Synthyris reniformis* var. *cordata* (S), *Penstemon rupicola* (E), *Cirsium acanthodontum* (S), *Galium bolanderi* (S), *Antennaria suffrutescens* (S), *A. rosea* (E), *Arnica parviflora* (S), *A. cernua* (S), *A. spathulata* (S), and *Senecio canus* (S).

SUMMARY OF PLANTS

Three hundred species of plants are known from Iron Mountain. Additions will probably be made as it is collected more extensively. The largest families present are Compositae (20 genera, 34 species), Ericaceae (13 genera, 27 species), Gramineae (18 genera, 29 species), Liliaceae (14 genera, 19 species), Saxifragaceae (9 genera, 12 species), Polypodiaceae (9 genera, 11 species), Cruciferae (8 genera, 9 species), Leguminosae (7 genera, 12 species). Other important families with total number of species are as follows: Rosaceae (9), Pinaceae (9), Orchidaceae (8), Scrophulariaceae (8), and Cyperaceae (7). The 300 species amount to nearly 10% of the total listed by Peck (1941) for the State of Oregon. Fifty-nine families are represented in the flora of Iron Mountain, or 50% of the total that occur in Oregon. This indicates a fairly diverse and well represented flora, considering the limited area which was studied.

Groups	Families	Genera	Species
Pteridophyta	3	11	13
Gymnospermae	3	8	13
Monocotyledonae	7	45	72
Dicotyledonae	46	129	202
Totals	59	193	300

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Analytical Key to the Families

Plants reproducing by spores ..... Division I. PTERIDOPHYTA
Plants reproducing by seeds ..... Division II. SPERMATOPHYTA

Division I. PTERIDOPHYTA

Stems jointed, hollow; leaves sheath-like; spores borne in terminal cones ..... 2. Equisetaceae
Stems not jointed, nor hollow; leaves not sheath-like; spores never in cones
  Leaves large, fern-like; sporangia borne on the under surface of the leaves ..... 1. Polypodiaceae
  Leaves small, scale-like; plant moss-like; sporangia borne in the leaf axils ..... 3. Selaginellaceae

Division II. SPERMATOPHYTA

Seeds not enclosed in an ovary, usually borne on the face of a cone scale ..... Class I. GYMNOSPERMAE
Seeds enclosed in an ovary ..... Class II. ANGIOSPERMAE

Class I. GYMNOSPERMAE

Fruit red, one-seeded, berry-like or drupe-like ..... 4. Taxaceae
Fruit a several-seeded cone
  Leaves scale-like ..... 6. Cupressaceae
  Leaves linear, fascicled or scattered along the branch ..... 5. Pinaceae

Class II. ANGIOSPERMAE

Leaves usually parallel veined, parts of the flower commonly in 3's, vascular bundles scattered throughout the stem, one seed leaf ..... Sub-class I. Monocotyledonae
Leaves usually netted veined, parts of the flower commonly in 4's or 5's, vascular bundles arranged concentrically around a central pith, two seed leaves ..... Sub-class II. Dicotyledonae

Subclass I. MONOCOTYLEDONAE

Inflorescence a fleshy spadix ..... 9. Araceae
Inflorescence not a spadix
  Plants grass-like; flowers inconspicuous
    Perianth none
      Stems hollow, cylindrical; leaves two-ranked; fruit a caryopsis ..... 7. Gramineae

Stems solid, usually three-angled; leaves three-ranked; fruit an achene ..... 8. Cyperaceae
Perianth present, glume like ..... 10. Juncaceae
Plants not grass-like; flowers generally quite showy
Ovary superior ..... 11. Liliaceae
Ovary inferior
Flowers regular (ours) ..... 12. Iridaceae
Flowers irregular ..... 13. Orchidaceae

Subclass II. DICOTYLEDONAE

PETALS NONE

Trees and shrubs
Flowers perfect, not borne in catkins ..... 24. Lauraceae
Flowers monoecious or dioecious, staminate or both staminate and pistillate flowers borne in catkins
Staminate flowers, only, borne in catkins
Fruit a nut in a scaly cup or bur ..... 15. Fagaceae
Fruit a nut in a leaf-like tubular involucre ..... 14. Betulaceae
Staminate and pistillate flowers both borne in catkins
Fruit a woody cone ..... 14. Betulaceae
Fruit berry-like ..... 41. Garryaceae
Herbs
Partial parasites growing on trees ..... 16. Loranthaceae
Not parasitic
Ovary superior
Pistil one ..... 18. Polygonaceae
Pistils many ..... 22. Ranunculaceae
Ovary inferior; leaves large and heart-shaped ..... 17. Aristolochiaceae

PETALS PRESENT

Petals free, or only slightly joined at base

Ovary superior
Stamens borne at the base of the calyx lobes and fused with other floral parts into a hypanthium
Stamens 12 or fewer ..... 28. Saxifragaceae
Stamens many ..... 29. Rosaceae
Stamens not borne as above and not fused into a hypanthium
Leaves tubular, hood-shaped above ..... 26. Sarraceniaceae
Leaves not tubular and hood-shaped
Sepals 2 (ours) ..... 19. Portulacaceae
Sepals more than 2
Aquatics with floating leaves ..... 21. Nymphaeaceae
Terrestrial plants
Plants with fleshy, very succulent leaves ..... 27. Crassulaceae
Plants with leaves not as above
Stamens indefinite in number
Pistil 1; stamens united into a tube around the pistil ..... 35. Malvaceae
Pistils many, stamens free ..... 22. Ranunculaceae
Stamens definite in number
Anthers opening by pores ..... 43. Ericaceae
Anthers opening by slits or sometimes valves
Leaves alternate
Petals 4 ..... 25. Cruciferae

Petals more than 4
Corolla irregular
Flowers with lower petal spurred at the base .....37. Violaceae
Flower papilionaceous (ours) .....30. Leguminosae
Corolla regular
Sepals united to form a disk; stamens 5 .....32. Anacardiaceae
Sepals free; stamens 6 .....23. Berberidaceae
Leaves opposite or basal
Stamens in groups; styles 3 .....36. Hypericaceae
Stamens not as above
Small trees (ours) .....33. Aceraceae
Herbs
Pistil 1, compound .....20. Caryophyllaceae
Pistils several, simple .....22. Ranunculaceae

Ovary inferior
Flowers in umbels, these sometimes paniculate
Stamens opposite the petals .....34. Rhamnaceae
Stamens alternate with the petals
Fruit a berry; umbels paniculate .....39. Araliaceae
Fruit not a berry; umbels simple or compound .....40. Umbelliferae
Flowers not in umbels
Fruit a pome .....29. Rosaceae
Fruit not as above
Perianth parts in 5's (occasionally 4's); styles 2-5 .....28. Saxifragaceae
Perianth parts in 4's (rarely 2's); style 1
Fruit fleshy; flowers surrounded by showy petal-like bracts; stamens 4 .....42. Cornaceae
Fruit dry; flowers in racemes or spikes; stamens 2 or 8; flower parts in 4's or 2's .....38. Onagraceae

Petals more or less united

Stamens more than 5
Petals united at base, 2 alike, the third forming a hood .....31. Polygalaceae
Petals united into an urn shaped tube .....43. Ericaceae

Stamens 5 or fewer
Ovary superior
Flowers regular
Pistils 2 .....46. Apocynaceae
Pistil 1
Ovary 4-lobed, forming 4 nutlets .....50. Boraginaceae
Ovary not 4-lobed, not as above
Stamens opposite the corolla lobes .....44. Primulaceae
Stamens alternate with the corolla lobes
Leaves all basal .....54. Plantaginaceae
Leaves not as above
Trailing or climbing herbs .....47. Convolvulaceae
Not trailing herbs, not as above
Locule 1
Plants glabrous .....45. Gentianaceae
Plants pubescent .....49. Hydrophyllaceae
Locules 2 to 5
Locules 3 or (2) .....48. Polemoniaceae
Locules 5 .....43. Ericaceae

Flowers irregular
Leaves alternate
Parasites with scalelike leaves ..... 53. Orobanchaceae
Not as above, plant with green leaves ..... 52. Scrophulariaceae
Leaves opposite
Ovary 4-lobed, forming 4 nutlets ..... 51. Labiatae
Ovary a capsule, not as above ..... 52. Scrophulariaceae
Ovary inferior
Leaves alternate or basal
Flowers bell-shaped ..... 58. Campanulaceae
Flowers involucrate and in heads ..... 59. Compositae
Leaves opposite or whorled
Stamens united into a ring or tube around the style ..... 59. Compositae
Stamens not united, not as above
Shrubs, erect or twining ..... 56. Caprifoliaceae
Herbs
Flower parts in 4's ..... 55. Rubiaceae
Flower parts not as above (corolla 5-lobed) ..... 57. Valerianaceae

Annotated Catalogue of Plants

PTERIDOPHYTA—Ferns and Fern-allies

1. POLYPODIACEAE—Fern Family

Indusium present
Sori marginal, covered by the revolute portion of the leaf
Fronds of two kinds
Sterile leaf blades simple pinnate ..... 4. *Blechnum*
Sterile leaf blades 2-3 pinnate ..... 8. *Cryptogramma*
Fronds alike
Plants with fan-shaped pinnules ..... 5. *Adiantum*
Plants with pinnules not as above
Plants large and stout; fronds usually solitary ..... 6. *Pteridium*
Plants small and slender; fronds generally clustered ..... 7. *Cheilanthes*
Sori not marginal, borne on the veins
Sori longer than broad or lunate
Sori small, oblong or lunate ..... 3. *Athyrium*
Sori large, chain-like ..... 9. *Woodwardia*
Sori round ..... 2. *Polystichum*
Indusium wanting ..... 1. *Polypodium*

1. POLYPODIUM L.

Fronds thin, 20-40 cm long; pinnae acute or acuminate, linear attenuate ....1. *P. glycyrrhiza*
Fronds small, 5-15 cm long; pinnae obtuse, short ..... 2. *P. hesperium*

1. *Polypodium glycyrrhiza* D. C. Eaton. Licorice fern.—Common, on rock outcrops of north slope near summit. Humid Transition to Canadian.

2. *Polypodium hesperium* Maxon. Mountain licorice fern.—Among rocks on northwest slope near summit; fairly common. Canadian.

2. POLYSTICHUM Roth.

1. *Polystichum munitum* (Kaulf.) Presl. Common sword fern.—Along Rock Creek on east slope at Smith Claim; very common. Humid Transition.

a. *Polystichum munitum* (Kaulf.) Presl. var. *imbricans* (D. C. Eaton) Maxon. Imbricated sword fern.—On east slope along Rock Creek, rocky northwest slope, and on summit under rocks; common. Humid Transition to Canadian.

b. *Polystichum munitum* (Kaulf.) Presl. var. *inciso-serratum* (D. C. Eaton) Underw.—Open east slope along Rock Creek; rare. Humid Transition.

3. ATHYRIUM Roth.

1. *Athyrium filix-femina* (L.) Roth. Lady-fern.—East slope growing beside a spring; common. Transition and Canadian.

4. BLECHNUM L.

1. *Blechnum spicant* L. Deer-fern.—Common along springs and water courses in deep shade. East slope near Smith Mine at a spring, also on shady southeast slope. Humid Transition.

5. ADIANTUM L.

1. *Adiantum pedatum* L. var. *aleuticum* Rupr. Western maidenhair fern.—East slope along Rock Creek at Smith Claim; fairly common. Humid Transition and Canadian.

6. PTERIDIUM Scop.

1. *Pteridium aquilinum* (L.) Kuhn. var. *pubescens* Underw. Western bracken.—Along banks of Rock Creek at Smith Claim in moist woods; very common. Humid Transition.

7. CHEILANTHES Sw.

Fronds densely tomentose beneath ..... 1. *C. gracillima*
Fronds glabrous on both surfaces ..... 2. *C. siliquosa*

1. *Cheilanthes gracillima* D. C. Eaton. Lace-fern.—On rock ledges at summit, also in like situations on south and southeast slopes; not uncommon. Canadian.

2. *Cheilanthes siliquosa* Maxon. Oregon cliff-brake.—Common on dry hillsides, east and southwest slope. Canadian.

8. CRYPTOGRAMMA R. Br.

1. *Cryptogramma acrostichoides* R. Br. American parsley-fern.—Northwest slope near summit, among rocks; also common on steep rocky hillsides overlooking Boulder Creek on south slope. Canadian.

9. WOODWARDIA J. E. Smith

1. *Woodwardia fimbriata* J. E. Smith. Giant chain-fern.—Creek bottoms on southwest slope; occasional. Arid Transition.

2. EQUISETACEAE.—Horsetail Family

1. EQUISETUM L.

1. *Equisetum telmateia* Ehrh. Giant horsetail.—Along moist roadside margins at Smith Claim on Rock Creek, east slope; fairly common. Humid Transition.

3. SELAGINELLACEAE—Selaginella Family

1. SELAGINELLA Beauv.

1. *Selaginella wallacei* Hieron. Wallace's selaginella.—On mossy rocks in open woods on south slope; also common at summit. Transition to Canadian.

SPERMATOPHYTA—Seed Plants

Class GYMNOSPERMAE —Cone-bearing plants

4. TAXACEAE—Yew Family

1. TAXUS L.

1. *Taxus brevifolia* Nutt. Western Yew.—East slope growing along banks of Rock Creek at Smith Claim; occasional. Humid Transition and Canadian.

5. PINACEAE—Pine Family

Leaves in fascicles, 2 to 5 in a bundle ..... 1. *Pinus*
Leaves solitary, opposite or whorled, scattered along the branch
  Branchlets smooth; leaves persistent when dried, bracts exceeding the scales ..... 2. *Pseudotsuga*
  Branchlets roughened by the persistent leaf bases; leaves deciduous when dried, scales longer than the bracts
    Leaves narrowed to a short petiole ..... 3. *Tsuga*
    Leaves sessile on a woody base ..... 4. *Picea*

1. PINUS L.

Leaves 5 in a fascicle
  Cones 1.5 to 2 dm long ..... 1. *P. monticola*
  Cones 3 to 5 dm long, or more ..... 2. *P. lambertiana*
Leaves 2 or 3 in a fascicle
  Leaves 3 in a fascicle
    Cones asymmetrical, persistent, and remaining closed ..... 3. *P. attenuata*
    Cones symmetrical, deciduous and opening at maturity
      Cones 7 to 15 cm long; prickles of the cone short and broad, turning outward ..... 4. *P. ponderosa*
      Cones 15 to 30 cm long; prickles of the cone long and narrow, turning inward ..... 5. *P. jeffreyi*
  Leaves 2 in a fascicle ..... 6. *P. contorta*

1. *Pinus monticola* Dougl. Western white pine.—The characteristic tree at higher elevations on the mountain. Common on west slope, as well as extending up southeast slope to summit; very common at all stations. Canadian.

2. *Pinus lambertiana* Dougl. Sugar pine.—Most common on south slope but extending around to east slope in scattered stands. The largest tree on the mountain. Probably as far west as it extends in this region. Transition and Lower Canadian.

3. *Pinus attenuata* Lemm. Knob-cone pine.—On southwest slope and at summit but to be noted on all high, dry ridges in this region; common but quite rare at higher elevations. Humid Transition.

4. *Pinus ponderosa* Dougl. Western yellow pine.—On east slope along

trail to the Smith place; not common. It has not been reported west of the Rogue River Mountains in this region. Arid Transition.

5. *Pinus jeffreyi* Murr. Jeffrey's pine.—High, dry ridges on south and southeast slopes, at higher elevations than *P. ponderosa*. It is present here on the very fringe of its range, not having been reported either to the west or north of our area. Upper Arid Transition and Canadian.

6. *Pinus contorta* Dougl. var. *murrayana* (Balf.) Engelm. Lodge-pole pine.—Along summit of a ridge extending southward from Iron Mountain. It ranges no farther west than this station in our region. It is here, in all probability, that transitional forms occur that indicate a close relationship with *P. contorta* (Coast pine). Canadian.

2. PSEUDOTSUGA Carr.

1. *Pseudotsuga taxifolia* (Lamb.) Britt. Douglas fir.—Very common at all stations on the mountain, extending up the slopes to the summit. The characteristic tree of the Humid Transition zone.

3. TSUGA (Engl.) Carr.

1. *Tsuga heterophylla* (Raf.) Sarg. Western hemlock.—Abundant on the lower east slope and along Rock Creek at Smith Claim. A climax tree in the coastal Humid Transition zone. Common in the Canadian zone of the Rogue River Mountains.

4. PICEA Link.

1. *Picea breweriana* Wats. Weeping spruce.—Common on the north and west slopes near summit. The occurrence of this rare tree on the mountain is very interesting. It has not previously been reported from the Rogue River Mountains although the habitat is identical to those in the Siskiyou and Chetco Ranges where it has been found. This species usually grows at elevations above 4000 feet. It is the rarest American spruce. Canadian.

6. CUPRESSACEAE—Cypress Family

Cones woody; leaves scale-like
  Cones oblong; scales oblong, imbricated; leaves appearing to be in whorls of four ..... 1. *Libocedrus*
  Cones globose; scales shield or wedge-shaped; leaves in pairs ..... 2. *Chamaecyparis*
Cones fleshy, berry-like ..... 3. *Juniperus*

1. LIBOCEDRUS Endl.

1. *Libocedrus decurrens* Torr. Incense cedar.—Present on east slope and on southeast slope along Steffans Meadow Trail; scattered. The characteristic tree of the Arid Transition zone.

2. CHAMAECYPARIS Spach.

1. *Chamaecyparis lawsoniana* Parl. Port Orford cedar.—On all slopes and extends up to the summit at 4000 feet. The Port Orford cedar is one of our more valuable lumber trees. Humid Transition to Canadian.

3. JUNIPERUS L.

1. *Juniperus communis* L. var. *montana* Ait. Dwarf Juniper.—A low shrub on the west and south slopes. Common on all dry stony sterile ridges in this area. Canadian.

Class ANGIOSPERMAE—Flowering Plants

MONOCOTYLEDONAE

7. GRAMINEAE—Grass Family

Spikelets with perfect flowers at the base
  Spikelets with several to many flowers
    Inflorescence a panicle
      Glumes shorter than the lemma; awn apical and straight or none at all ..... Tribe 1. Festuceae
      Glumes longer than the lemma; awn dorsal, bent and twisted ..... Tribe 3. Aveneae
    Inflorescence a spike ..... Tribe 2. Hordeae
  Spikelets with one perfect flower ..... Tribe 4. Agrostideae
Spikelets with perfect flowers at the top ..... Tribe 5. Phalarideae

Tribe 1. FESTUCEAE

Lemmas keeled on the back
  Spikelets strongly compressed, crowded in dense, one-sided clusters ..... 5. *Dactylis*
  Spikelets not as above
    Lemmas awned from a minutely bifid apex ..... 1. *Bromus*
    Lemmas awnless; spikelets small not over 8 mm long ..... 4. *Poa*
Lemmas rounded on the back (slightly keeled toward the summit in *Festuca* and some species of *Bromus*)
  Glumes papery; upper florets sterile, folded about each other ..... 6. *Melica*
  Glumes not papery; upper florets perfect
    Nerves of the lemma converging at the apex
      Lemmas entire, awned from the tip or pointed ..... 2. *Festuca*
      Lemmas awned from a minutely bifid apex ..... 1. *Bromus*
    Nerves of the lemma not converging; lemma awnless ..... 3. *Glyceria*

Tribe 2. HORDEAE

Spikelet 1 at each joint of the rachis ..... 8. *Lolium*
Spikelets more than 1 at each joint of the rachis ..... 7. *Elymus*

Tribe 3. AVENEAE

Spikelets with 1 perfect flower, the other staminate ..... 11. *Holcus*
Spikelets with 2 or more perfect flowers
  Lemmas bidentate, awned from above the middle ..... 9. *Trisetum*
  Lemmas acute, awned from below the middle ..... 10. *Aira*

Tribe 4. AGROSTIDEAE

Inflorescence spike-like, very dense and compact
  Glumes awned
    Glumes short awned ..... 15. *Phleum*
    Glumes long awned ..... 13. *Polypogon*
  Glumes not awned ..... 14. *Alopecuris*
Inflorescence not spike-like, or at least not very dense and compact
  Florets with tuft of hairs at the base at least half as long as the lemma; palea present ..... 16. *Calamagrostis*

Florets naked at the base or with short hairs ..... 12. *Agrostis*

Tribe 5. PHALARIDEAE

Lower florets staminate; spikelets brown and shining ..... 17. *Hierochloe*
Lower florets sterile; spikelets green or yellowish ..... 18. *Anthoxanthum*

1. BROMUS L.

Introduced annuals
- Awns 6 to 9 mm long ..... 2. *B. mollis*
- Awns 20 to 30 mm long ..... 1. *B. tectorum*

Native perennial ..... 3. *B. vulgaris*

1. *Bromus tectorum* L. Downy cheat grass.—Open hillside on the east slope; very common. Introduced from Europe.

2. *Bromus mollis* L. Soft cheat grass.—Dry roadside on south slope. Introduced from Europe.

3. *Bromus vulgaris* (Hook.) Shear. Narrow-flowered brome-grass.—Open woods and dry hillsides on east slope; common. Humid Transition.

2. FESTUCA L.

Plants annual; stamen usually one
- Upper margins of the lemma ciliate ..... 1. *F. megalura*
- Upper margins of the lemma not ciliate ..... 4. *F. dertonensis*

Plants perennial; stamens three
- Blades narrow 2.5 mm wide or less; sheaths smooth ..... 2. *F. occidentalis*
- Blades 3 to 6 mm wide; sheaths villous at the throat ..... 3. *F. californica*

1. *Festuca megalura* Nutt. Western six-weeks fescue.—Dry open hillside on east slope; quite common. Humid Transition.

2. *Festuca occidentalis* Hook. Western fescue.—Open ground and hillsides on east slope; scattered. Transition to Canadian.

3. *Festuca californica* Vas. California fescue.—On dry open hillside, east slope; occasional. Transition.

4. *Festuca dertonensis* (All.) Asch. & Graebn. Six-weeks fescue.—Dry ground on south slope; fairly common. Transition.

3. GLYCERIA R. Br.

Lemmas 7-nerved ..... 1. *G. elata*
Lemmas 5-nerved ..... 2. *G. pauciflora*

1. *Glyceria elata* (Nash) Hitchc. Tall manna-grass.—Marshy ground along Rock Creek at Smith Claim on east slope; infrequent. Transition to Canadian.

2. *Glyceria pauciflora* Presl. Few-flowered manna-grass.—Wet swampy ground on south slope; local in this type of habitat. Transition.

4. POA L.

Lemma with web-like hairs at the base
- Blades involute, lemmas 4 to 5 mm long ..... 1. *P. rhizomata*
- Blades flat; lemmas 3 to 4 mm long ..... 3. *P. pratensis*

Lemma without web-like hairs ..... 2. *P. pattersonii*

1. *Poa rhizomata* Hitchc. Timber bluegrass.—Common on dry open hillside, east slope. Humid Transition and Canadian.

2. *Poa pattersonii* Vas. Patterson's bluegrass.—Found only at the summit; fairly rare. Arid Transition and Canadian.

3. *Poa pratensis* L. Kentucky bluegrass.—Dry hillside, east slope. Common. Transition to Canadian.

5. DACTYLIS L.

1. *Dactylis glomerata* L. Orchard-grass.—On roadside below Smith Claim on east slope; local. Introduced from Europe.

6. MELICA L.

Glumes narrow; lemmas acuminate ..... 1. *M. subulata*
Glumes broad; lemmas obtuse ..... 2. *M. geyeri*

1. *Melica subulata* (Griseb.) Scribn. Alaska onion-grass.—Fairly common on east slope. Transition to Canadian.

2. *Melica geyeri* Munro. Geyer's noion-grass.—Dry open woods on east slope; rather scarce. Canadian.

7. ELYMUS L.

1. *Elymus glaucus* Buckl. Western rye-grass.—Open woods along banks of Rock Creek on east slope. Transition.

8. LOLIUM L.

1. *Lolium perenne* L. English rye-grass.—On south slope in road, not common. Introduced from Europe.

9. TRISETUM Pers.

1. *Trisetum canescens* Buckl. Tall trisetum.—Common in open woods of east slope. Transition.

10. AIRA L.

1. *Aira caryophyllea* L. Silver hair-grass.—In yard of Smith Claim on east slope; common in dry open ground. Introduced from Europe.

11. HOLCUS L.

1. *Holcus lanatus* L. Velvet grass.—Along roadside at Smith Claim on east slope; quite common. Introduced from Europe.

12. AGROSTIS L.

Palea present, well developed ..... 1. *A. tenuis*
Palea wanting, or minute
  Plants with rhizomes ..... 2. *A. hallii*
  Plants without rhizomes ..... 3. *A. exarata*

1. *Agrostis tenuis* Sibth. Colonial bent-grass.—Low moist ground along Rock Creek at Smith Claim; common. Probably introduced from Europe.

2. *Agrostis hallii* Vas. Hall's bent-grass.—Common in open woods on south slope. Humid Transition.

3. *Agrostis exarata* Trin. Western bent-grass.—East slope on moist ground along Rock Creek at Smith Claim; fairly common. Humid Transition.

13. POLYPOGON Desf.

1. *Polypogon monspeliensis* (L.) Desf. Annual beard-grass.—Roadside on Coquille-Rogue River Divide; quite abundant locally. Introduced from Europe.

14. ALOPECURIS L.

1. *Alopecuris geniculatus* L. Water foxtail.—Low wet ground along Rock Creek at Smith Claim, east slope; infrequent. Transition.

15. PHLEUM L.

1. *Phleum alpinum* L. Alpine timothy.—Moist ground on west slope near summit; rare. Canadian.

16. CALAMAGROSTIS Adans.

1. *Calamagrostis nutkaensis* (Presl.) Steud. Pacific reed grass.—Common in local situations on east slope along Rock Creek. Confined to wet marshy ground. Transition to Canadian.

17. HIEROCHLOE R. Br.

1. *Hierochloe occidentalis* Buckl. Western vanilla-grass.—Present on east slope along banks of Rock Creek at Smith Claim; occasional. Canadian.

18. ANTHOXANTHUM L.

1. *Anthoxanthum odoratum* L. Sweet vernal grass.—East slope along banks of Rock Creek at Smith Claim, also found on dry open hillside on the south slope; frequent. Introduced from Europe.

8. CYPERACEAE—Sedge family

Flowers monoecious or dioecious; achenes enclosed in a sac (perigynium) ..... 2. *Carex*
Flower perfect; achenes not enclosed in a sac; perianth bristles present (in ours) .....
..... 1. *Scirpus*

1. SCIRPUS (Tourn.) L.

Bristles 4, barbs pointed downward ..... 1. *S. microcarpus*
Bristles 6 to 10, barbs pointed upward or bristles nearly smooth ..... 2. *S. criniger*

1. *Scirpus microcarpus* Presl. Small-fruited bulrush.—Marshy swale along Rock Creek on east slope. Transition.

2. *Scirpus criniger* A. Gray. Fringed bulrush.—South and east slopes at springs and on wet marshy or swampy ground. Canadian.

2. CAREX (Rupp.) L.

Stigmas 3; achenes 3-angled
  Style continuous with the achene, hardened and persistent; beak of the peryginia tapering, 1.5 to 2 mm long, deeply bidentate ..... 1. *C. exsiccata*
  Style jointed with the achene, withering and deciduous, peryginia abruptly beaked and short bidentate
    Lower bracts short sheathing ..... 2. *C. amplifolia*
    Lower bracts long sheathing about equalling the culm ..... 3. *C. mendocinensis*

Stigmas 2; achene lenticular
Lateral spikes sessile, ovoid; peryginia winged, tapering into a beak one-third the length of the whole, beak bidentate ..... 4. *C. festivella*
Lateral spikes peduncled, cylindric, peryginia not winged, abruptly and minutely beaked, beak entire ..... 5. *C. obnupta*

1. *Carex exsiccata* Bailey. Western inflated sedge.—Moist soil of a dried up pond on south slope; common. Humid Transition.

2. *Carex amplifolia* W. Boott. Ample-leaved sedge.—East slope along Rock Creek; fairly common. Transition.

3. *Carex mendocinensis* Olney ex W. Boott. Mendocino sedge.—This is perhaps the commonest sedge on the mountain. It is particularly abundant on the east slope in marshy ground along Rock Creek at Smith Claim. Transition. —*C. debiliformis* Mack.

4. *Carex festivella* Mack. Mountain meadow sedge.—East slope, marshy ground along Rock Creek at Smith Claim; scattered. Transition.

5. *Carex obnupta* Bailey. Slough sedge.—Wet creek bottom on south slope; very common. Humid Transition.

9. ARACEAE—Arum Family

1. LYSICHITUM Schott.

1. *Lysichitum americanum* Hulten & St. John. Yellow skunk cabbage.—Swampy ground on southwest slope, along a creek at a trail crossing; occasional. Canadian.

10. JUNCACEAE—Rush Family

Leaf-sheaths open; capsule 1- or 3-celled, many seeded; stems usually pithy ..... 1. *Juncus*
Leaf-sheaths closed; capsule 1-celled, 3-seeded; stems hollow ..... 2. *Luzula*

1. JUNCUS L.

Lower leaf of the inflorescence appearing like a continuation of the stem; inflorescence therefore appearing lateral ..... 1. *J. effusus*
Lower leaf not as above; inflorescence therefore appearing terminal
Plants perennial, with simple stems ..... 2. *J. ensifolius*
Plants annual; stems branching ..... 3. *J. bufonius*

1. *Juncus effusus* L. var. *pacificus* Fern. & Weig. Common rush.—East slope along Rock Creek below Smith Claim; very common. Canadian.

2. *Juncus ensifolius* Wiks. Three-stamened rush.—East slope along road to summit; common. Transition to Canadian.

3. *Juncus bufonius* L. Toad rush.—Low marshy ground at Smith Claim on east slope. Humid Transition.

2. LUZULA DC.

Flowers in a loose panicle, solitary on the end of the branches ..... 1. *L. parviflora*
Flowers congested into spikes or head-like clusters ..... 2. *L. multiflora*

1. *Luzula parviflora* (Ehrh.) Desv. Small-flowered wood-rush.—Common on east slope above Rock Creek on wooded hillsides. Humid Transition and Canadian.

2. *Luzula multiflora* (Retz.) Lejeune. Common woodrush.—Very common at all stations, from lower elevations to summit. Transition to Canadian. —*L. campestris* (L.) DC. of most American authors.

11. LILIACEAE—Lily Family

Fruit a capsule
- Leaves whorled (or some alternate in *Lilium*)
  - All leaves in one whorl of 3 ..... 14. *Trillium*
  - Leaves in several whorls, or some alternate ..... 8. *Lilium*
- Leaves not whorled
  - Plants with rhizomes
    - Leaves broad, heavily nerved, elliptic; flowers paniculate ..... 5. *Veratrum*
    - Leaves narrow or grass-like; flowers racemose
      - Leaves few, entire, equitant
        - Flowers yellow ..... 1. *Narthecium*
        - Flowers white ..... 3. *Tofieldia*
      - Leaves grass-like, very numerous, serrulate, not equitant ..... 2. *Xerophyllum*
  - Plants with bulbs
    - Flowers in umbels ..... 6. *Brodiaea*
    - Flowers not in umbels
      - Leaves broad, not grass-like
        - Leaves only 2, broad, appearing basal ..... 9. *Erythronium*
        - Leaves several to many, not basal; stem leafy ..... 8. *Lilium*
      - Leaves narrow, appearing grass-like
        - Flowers showy; perianth segments unlike ..... 7. *Calochortus*
        - Flowers small; perianth segments alike ..... 4. *Zigadenus*

Fruit a berry
- Plants with leafy stems
  - Flowers drooping, axillary or terminal
    - Flowers axillary ..... 13. *Streptopus*
    - Flowers terminal, 1 to 2 at end of stem ..... 12. *Disporum*
  - Flowers erect, racemose or paniculate ..... 11. *Smilacina*
- Plants with few leaves, mostly basal ..... 10. *Clintonia*

1. NARTHECIUM Moeh.

1. *Narthecium californicum* Baker. California bog-asphodel.—Marshy ground on east slope along road to summit; common. This plant has not hitherto been recorded from as far north as Coos County. It is a representative of the California element in our flora.

2. XEROPHYLLUM Michx.

1. *Xerophyllum tenax* (Pursh) Nutt. Bear-grass (fig. 9).—East slope, along Rock Creek at Smith Claim, also on hillsides on south slope; very common. Canadian.

3. TOFIELDIA Huds.

1. *Tofieldia occidentalis* S. Wats. Western tofieldia.—Common in all marshes on the mountain. Found on east slope along road to summit and grow in marshy ground at McCurdy Camp. Canadian.

4. ZIGADENUS Michx.

1. *Zigadenus fremontii* (Torr.) Torr. Fremont's star lily.—Dry ground,

on open south slope. A representative of the California element. It is found throughout the Coast Range from the mouth of the Coquille River to southern California. Canadian in our region.

5. VERATRUM L.

1. *Veratrum insolitum* Jeps. Siskiyou false hellebore (fig. 10).—Open brushy hillsides on east and south slopes. A representative of the California element in our flora. Humid Transition to Canadian.

6. BRODIAEA Sm.

1. *Brodiaea coronaria* (Salisb.) Jeps. Harvest lily.—Dry open hillsides on southwest slope; common. This plant ranges from Vancouver Island to southern California along the Pacific Coast. Humid Transition.

7. CALOCHORTUS Pursh

1. *Calochortus tolmiei* H. & A. Oregon mariposa lily.—Along Middle Elk Road, and east slope at Smith Claim on Rock Creek, also quite common on south slope, dry open hillsides. Transition.

8. LILIUM L.

Flowers erect perianth parts only slightly recurved; anthers 3 mm long .....1. *L. parvum*
Flowers nodding; perianth parts revolute to below the middle
Perianth 4 to 5 cm long; anthers 5 to 6 mm long; ovary 9 to 12 mm long .....
.....2. *L. columbianum*
Perianth 5 to 8 cm long; anthers 10 to 15 mm long; ovary 20 to 25 mm long .....
.....3. *L. pardalinum*

1. *Lilium parvum* Kell. Small tiger lily.—East slope, along Rock Creek at Smith Claim; occasional. About as far north as this species occurs. It represents the California element in our flora.

Figs. 9-10.—9. *Xerophyllum tenax*, south slope on Ranger saddle. 10. *Veratrum insolitum*, open woods on south saddle.

2. *Lilium columbianum* Hanson. Columbia lily.—Open woods on east slope above Rock Creek. The most common lily of this genus. It is found from British Columbia to northern California. Humid Transition to Canadian.

3. *Lilium pardalinum* Kell. Leopard lily.—Quite common along streams and at springs. On southwest slope at McCurdy Camp and along banks of Rock Creek at Smith Claim on east slope. Transition to Canadian. Californian element.

9. ERYTHRONIUM L.

1. *Erythronium oregonum* Appleg. Giant fawn lily.—East slope at Smith Claim on Rock Creek. Roadsides to summit and in open woods where it is plentiful early in the growing season. It but rarely occurs south of our region and is to be considered as a representative of the Northern element.

10. CLINTONIA Raf.

1. *Clintonia uniflora* (Schult.) Kunth. Queen's cup.—At a spring on east slope at Smith Mine; not common. Canadian.

11. SMILACINA Desf.

Inflorescence a few-flowered raceme ..... 1. *S. sessilifolia*
Inflorescence a many-flowered panicle ..... 2. *S. racemosa*

1. *Smilacina sessilifolia* (Baker) Nutt. Small false Solomon's seal.—Common on east slope along Rock Creek at Smith Claim. Humid Transition and Canadian.

2. *Smilacina racemosa* (L.) Desf. Large false Solomon's seal.—Summit and on east slope along Rock Creek below Smith Claim; frequent. Humid Transition.

12. DISPORUM Salisb.

Flowers white; stigma 3-lobed at apex ..... 1. *D. smithii*
Flowers green; stigma entire ..... 2. *D. hookeri*

1. *Disporum smithii* (Hook.) Piper. Fairy lanterns.—Woods and along streams on east slope; not common. Humid Transition.

2. *Disporum hookeri* (Torr.) Britt. Hooker's fairy bells.—East and south slopes growing on dry wooded hillsides; very common. It is found from Douglas County to central California. This plant best represents the California element in our flora. Canadian.

13. STREPTOPUS Michx.

1. *Streptopus amplexifolius* (L.) DC. Twisted stalk.—East slope growing along Rock Creek in marshy ground; not common. Canadian.

14. TRILLIUM L.

Leaves nearly sessile ..... 1. *T. ovatum*
Leaves distinctly petioled ..... 2. *T. rivale*

1. *Trillium ovatum* Pursh. Wood lily.—East slope on Smith Claim up to the summit, in open woods; frequent. Humid Transition and Canadian.

2. *Trillium rivale* S. Wats. Brook wood lily.—Woods along Rock Creek

below Smith Claim on east slope and on wooded hillsides of south slope. This species reaches its northern limit in our area. It represents the California element in the flora.

12. IRIDACEAE—Iris Family

Styles petal-like; stems terete ..... 1. *Iris*
Styles filiform; stems flattened ..... 2. *Sisyrinchium*

1. IRIS L.

1. *Iris innominata* Hend. Golden iris.—Dry open woods, on hillsides of south and east slopes. This species represents an interesting endemic and is one of a group of plants which has a limited range in Curry and adjacent Coos Counties. Transition to Canadian.

2. SISYRINCHIUM L.

1. *Sisyrinchium sarmentosum* Suksd. Blue-eyed grass.—Occasional in wet places on south slope. This species is found more commonly east of the Cascades but appears sparingly in the coastal mountains. Canadian.—*S. idahoense* Bickn.

13. ORCHIDACEAE—Orchid Family

Plants with green foliage leaves present
  Stamens 2; lower lip large and inflated ..... 1. *Cypripedium*
  Stamen 1
    Leaf and flower solitary ..... 6. *Calypso*
    Leaves two to many, flowers many
      Leaves 2, opposite, borne near middle of stem ..... 4. *Listera*
      Leaves several, alternate or basal
        Flowers spurred ..... 2. *Habenaria*
        Flowers not spurred ..... 3. *Goodyera*
Plants with leaves reduced to scales ..... 5. *Corallorhiza*

1. CYPRIPEDIUM L.

1. *Cypripedium californicum* A. Gray. California lady's slipper.—East slope along Rock Creek at Smith Claim, also at site of spring on a hillside overlooking Rock Creek; extremely rare. This is one of our largest and most beautiful lady's slippers. It ranges just to the north of our station and appears to be limited to the Siskiyou-Rogue River Mountains in our area. Californian element. Canadian.

2. HABENARIA Willd.

Leaves basal; stem leaves bract-like, usually withered by flowering time ..... 1. *H. unalascensis*
Leaves not basal; stems leafy; leaves not withered at flowering time ..... 2. *H. sparsiflora*

1. *Habenaria unalascensis* (Spreng.) S. Wats. Alaska bog orchid.—Dry ground in woods of south slope and near summit; common. In this species the spur about equals the lip. Canadian.

a. *Habenaria unalascensis* (Spreng.) S. Wats. var. *elata* (Jeps.) Correll. Slender Alaska bog orchid.—Dry open woods at Smith Claim on east slope, and in woods of south slope; common. Differs from *H. unalascensis* in having the spur twice as long as the lip. Transition.—*H. elegans* (Lindl.) Boland.

2. *Habenaria sparsiflora* S. Wats. Sparse-flowered bog orchid.—Along roadside in mountain marshes with *Ledum* and *Chrysamphora*, east slope; fairly common. Canadian.

3. GOODYERA R. Br.

1. *Goodyera oblongifolia* Raf. Rattlesnake plantain.—Dense woods at almost all stations and elevations; common Transition to Canadian in our area. —*G. decipiens* (Hook.) F. T. Hubbard.

4. LISTERA R. Br.

1. *Listera caurina* Piper. Northwestern twayblade.—In woods of southeast slope; not common. Canadian.

5. CORALLORHIZA R. Br.

Lip purple-striped; spur none ..... 1. *C. striata*
Lip purple, not striped; spur present ..... 2. *C. mertensiana*

1. *Corallorhiza striata* Lindl. Striped coral root.—Woods on south slope; infrequent. Canadian.

2. *Corallorhiza mertensiana* Bong. Purple coral root.—This is the most common coral root in our area. Woods of the southeast slope. Canadian.

6. CALYPSO Salisb.

1. *Calypso bulbosa* (L.) Oakes. Angel slipper.—Woods above Smith Claim on Rock Creek, east slope, and on mossy rocks in Bonanza Basin, south slope. Canadian.

DICOTYLEDONEAE

14. BETULACEAE—Birch Family

Fruit a nut, enclosed in a leafy involucre ..... 1. *Corylus*
Fruit a woody cone, involucre none ..... 2. *Alnus*

1. CORYLUS L.

1. *Corylus californica* (A. DC.) Rose.—Western hazel.—Roadside along Middle Elk Road on Coquille-Rogue River Divide; common. Humid Transition.

2. ALNUS Hill

1. *Alnus rubra* Bong. Red alder.—East slope along Rock Creek at Smith Claim; very common. Humid Transition.

15. FAGACEAE—Oak Family

Fruit an acorn in an open scaly cup
  Staminate catkins drooping, loosely-flowered; pistillate flowers borne above the staminate catkins in axillary clusters, or solitary ..... 1. *Quercus*
  Staminate catkins erect, densely-flowered; pistillate flowers borne at the base of the staminate catkins ..... 2. *Lithocarpus*
Fruit 1-3 nuts enclosed in a spiny bur-like involucre ..... 3. *Castanopsis*

1. QUERCUS L.

Tall shrub or tree ..... 1. *Q. chrysolepis*

Low shrubs
Leaves 6 to 12 cm long ..... 2. *Q. sadleriana*
Leaves 2 to 3 cm long ..... 3. *Q. vaccinifolia*

1. *Quercus chrysolepis* Liebm. Canyon oak.—Dry open hillsides on south slope. This oak represents the California element in our flora. The writer has found it growing as far north as Paradise Camp north of the Umpqua River. It is known in Douglas, Curry, and Josephine Counties within the State of Oregon, and ranges south nearly throughout California. Transition.

2. *Quercus sadleriana* R. Br. Sadler's oak.—South slope on dry open hillsides. This rare oak is limited to the Siskiyou and Rogue River Mountains, and is thus a narrow endemic with a very restricted range. Another representative of the California element in our region. Canadian.

3. *Quercus vaccinifolia* Kell. Huckleberry or holly oak.—South and west slopes to the summit. Usually considered to be limited to the Siskiyous of Josephine and Curry Counties in Oregon and to the Trinity and southern Sierra Nevadas in California. It is quite common throughout the Rogue River Mountains, however, and the writer has found numerous stations for it in Douglas County as well. Californian element. Canadian.

2. LITHOCARPUS Blume.

1. *Lithocarpus densiflora* (H. & A.) Rehd. Tanbark oak.—East slope on hillside above Middle Elk Road at Smith Claim on Rock Creek, also south slope near summit. It is a shrub at this elevation. Tanbark oak represents the California element in our flora, and is common from Douglas County southward. Lower Canadian and Transition.

3. CASTANOPSIS Spach.

1. *Castanopsis chrysophylla* (Dougl.) A. DC. Giant chinquapin.—South slope on open hillside, and on west slope near summit; very common. Canadian and Humid Transition.

16. LORANTHACEAE—Mistletoe Family

1. ARCEUTHOBIUM Marsch-Bieb.

Plants parasitic on *Pinus attenuata* ..... 1. *A. americanum*
Plants parasitic on *Tsuga heterophylla* ..... 2. *A. tsugense*

1. *Arceuthobium americanum* Nutt. Pine mistletoe.—Fairly common on southwest slope, growing parasitically on *Pinus attenuata*. Humid Transition.

2. *Arceuthobium tsugense* (Rosend.) G. N. Jones. Hemlock mistletoe.—East slope at Smith Claim on Rock Creek, growing on *Tsuga heterophylla*; occasional. Humid Transition.

17. ARISTOLOCHIACEAE—Dutchman's Pipe Family

1. ASARUM L.

1. *Asarum caudatum* Lindl. Wild ginger.—Moist shady woods on south slope, usually along stream banks; fairly common. Transition and Canadian.

18. POLYGONACEAE—Buckwheat Family

Leaves with stipules wanting; flowers involucrate ..... 1. *Eriogonum*
Leaves with stipules present and sheath-like; flowers not involucrate
  Sepals 6, unequal; stigmas tufted ..... 2. *Rumex*
  Sepals 5, equal; stigmas capitate ..... 3. *Polygonum*

1. ERIOGONUM Michx.

1. *Eriogonum nudum* Dougl. Naked eriogonum.—Southwest slope to summit; occasional. Transition and Upper Sonoran.

2. RUMEX L.

Plants small; leaves hastate ..... 1. *R. acetosella*
Plants coarse; leaves not hastate
  Margins of inner perianth parts entire ..... 2. *R. conglomeratus*
  Margins of inner perianth parts with teeth or bristles ..... 3. *R. obtusifolius*

1. *Rumex acetosella* L. Sour dock.—Roadside at Smith Claim on east slope; common. Introduced from Europe.

2. *Rumex conglomeratus* Murr. Clustered dock.—Roadside on east slope along Rock Creek. Introduced from Europe.

3. *Rumex obtusifolius* L. Broad-leaved dock.—Along Middle Elk Road on the Coquille-Bogue River Divide; also on east slope along Rock Creek at Smith Claim; common. Introduced from Europe.

3. POLYGONUM L.

1. *Polygonum spergulariaeforme* Meisn. Fall knotweed.—Dry hillsides on southwest slope; occasional. Transition.

19. PORTULACACEAE—Purslane Family

1. MONTIA L.

Stem leaves 2, opposite ..... 1. *M. sibirica*
Stem leaves several, alternate
  Petals 12 to 14 mm long; stem leaves broadly ovate or orbicular ..... 2. *M. flagellaris*
  Petals 7 to 8 mm long; stem leaves linear to oblanceolate ..... 3. *M. parvifolia*

1. *Montia sibirica* (L.) Howell. Candy flower.—Growing along Rock Creek at Smith Claim on east slope; common. Transition.

2. *Montia flagellaris* (Bong.) Robins. Long-branched montia.—East slope, growing on rock cliff near summit. Ranges from Curry County north to Alaska, and represents the Northern element in our flora. Canadian.

3. *Montia parvifolia* (Moc.) Greene. Small-flowered montia.—East slope, growing on wet hillside below a spring, also on moist rock overlooking Smith Claim on Rock Creek. Somewhat similar to the preceding, but much more abundant and with a wider distribution. Humid Transition and Canadian.

20. CARYOPHYLLACEAE—Pink Family

Sepals free or united only at the base
  Stipules present ..... 1. *Spergularia*
  Stipules none ..... 2. *Arenaria*
Sepals united into a tube ..... 3. *Silene*

1. SPERGULARIA J. & C. Presl.

1. *Spergularia rubra* (L.) J. & C. Presl. Pink matweed.—East slope, growing in yard of Smith Claim along Rock Creek. Introduced from Europe.

2. ARENARIA L.

Leaves narrowly linear, stiff; plants glandular-hairy throughout ..... 1. *A. nuttallii*
Leaves ovate to lanceolate, soft; plants not glandular-hairy ..... 2. *A. macrophylla*

1. *Arenaria nuttallii* Pax. var. *gregaria* (Hel.) Jeps. Nuttall's sandwort.—On high rocky ridges of south slope; not common. This variety is found in southern Josephine and Curry Counties in our limits, and represents the California element. Canadian.

2. *Arenaria macrophylla* Hook. Large-leaved sandwort.—Open woods on south slope; common. Canadian.

3. SILENE L.

1. *Silene campanulata* S. Wats. Bell-shaped catchfly.—Dry ridges on south slope; occasional. This is a plant of the California element. It ranges as far north as Lane County in Oregon and south into Mendocino County in California. Canadian.

21. NYMPHAEACEAE—Water-lily Family

1. NUPHAR Smith

1. *Nuphar polysepalum* Engelm. Western yellow pond-lily.—In pond on southwest slope at McCurdy Camp. Has a rather wide distribution in ponds and lakes from low to fairly high altitudes. Canadian here.—*Nymphaea polysepala* (Engelm.) Greene.

22. RANUNCULACEAE—Buttercup Family

Pistils numerous, 1-ovuled, fruit an achene
  Petals present ..... 1. *Ranunculus*
  Petals absent; sepals petal-like ..... 2. *Anemonte*
Pistils few, 2 to many-ovuled; fruit a follicle
  Petals spurred, showy ..... 3. *Aquilegia*
  Petals not spurred, linear ..... 4. *Coptis*

1. RANUNCULUS (Tourn.) L.

1. *Ranunculus occidentalis* Nutt. Western buttercup.—Moist ground on east slope; along Rock Creek at Smith Claim; common. Humid Transition.

2. ANEMONE L.

Stem leaves simple ..... 1. *A. deltoidea*
Stem leaves compound ..... 2. *A. adamsiana*

1. *Anemone deltoidea* Hook. Wind-flower.—Southwest slope along Boulder Creek in moist open woods; fairly common. Canadian.

2. *Anemone adamsiana* Eastw. Adam's anemone.—Open woods, south slope; also east slope at Smith Claim on Rock Creek; abundant in early spring. One of the first plants to blossom. This windflower is limited to the Siskiyou and Rogue River Mountains and represents the California element. Canadian.

3. AQUILEGIA (Tourn.) L.

1. *Aquilegia formosa* Fisch. Columbine.—East slope on hillside above Smith Claim, also on south slope and along banks of Rock Creek. This species is found up to the summit at 4000 feet; abundant. Canadian.

4. COPTIS Salisb.

1. *Coptis laciniata* A. Gray. Western gold-thread.—South slope along Boulder Creek in Bonanza Basin and on east slope at Smith Claim on Rock Creek; common. Canadian.

23. BERBERIDACEAE—Barberry Family

Shrubs; leaves evergreen, spiny ..... 1. *Berberis*
Herbs; leaves not as above
  Leaflets 3; flowers in a spike ..... 2. *Achlys*
  Leaflets many; flowers in a panicle ..... 3. *Vancouveria*

1. BERBERIS L.

Leaflets 9 to 17, appearing palmately veined ..... 1. *B. nervosa*
Leaflets 5 to 9; strongly netted-veined, under surface densely papillose ..... 2. *B. piperiana*

1. *Berberis nervosa* Pursh. Mountain oregon grape.—Common in heavily wooded areas on east slope. Humid Transition.

2. *Berberis piperiana* (Abr.) Peck. Piper's oregon grape.—East slope; common on open hillsides and banks. First record of this species in Coos County. It appears to be the most common species in the Siskiyou and Rogue River Mountains, except for *Berberis nervosa*, and apparently entirely replaces *B. aquifolium* in our limits. Arid Transition to Canadian.

2. ACHLYS DC.

1. *Achlys triphylla* (Sm.) DC. Vanilla-leaf.—East slope, on edge of marsh along Rock Creek. Very abundant, forming dense patches in deep coniferous woods nearly to summit. Humid Transition to Canadian.

3. VANCOUVERIA Morr. & Dec.

Panicle glabrous; leaves thin ..... 1. *V. hexandra*
Panicle glandular-pubescent; leaves thick ..... 2. *V. planipetala*

1. *Vancouveria hexandra* (Hook.) Morr. & Dec. Inside-out-flower.—East slope, along Rock Creek at Smith Claim. Humid Transition and Canadian.

2. *Vancouveria planipetala* Calloni. Small-flowered inside-out-flower.—East slope, marshy ground along Rock Creek. This is the first time the plant has been reported from the Rogue River Mountains in Coos County. It ranges south into California and represents the Southern element in our flora.

24. LAURACEAE—Laurel Family

1. UMBELLULARIA Nutt.

1. *Umbellularia californica* (H. & A) Nutt. California laurel.—South and southwest slopes; fairly common. In our area on the mountain this species assumes a shrubby form and never reaches tree size. It ranges from California north to Douglas County in Oregon. A species of the California element. Humid Transition and Canadian.

25. CRUCIFERAE—Mustard Family

Pod short, less than twice as long as broad, a silicle
- Silicle distinctly flattened
  - Seeds only 1 to each cell ..... 1. *Lepidium*
  - Seeds many in each cell ..... 2. *Capsella*
- Silicle strongly inflated ..... 3. *Camelina*

Pod over four times longer than broad, a silique
- Flowers yellow, cream colored or orange
  - Some of the leaves deeply cleft or pinnately lobed
    - Pods with a distinct beak ..... 4. *Brassica*
    - Pods beakless, or nearly so ..... 5. *Descurainia*
  - All of the leaves entire or merely toothed ..... 6. *Erysimum*
- Flowers white, pink or purple
  - Leaves all with petioles present ..... 7. *Dentaria*
  - Stem leaves auriculate-clasping; flowers purplish ..... 8. *Streptanthus*

1. LEPIDIUM (Tourn.) L.

1. *Lepidium perfoliatum* L. Yellow-flowered peppergrass.—East slope, yard of Smith Claim on Rock Creek. This species grows abundantly in eastern Oregon and is occasionally adventive in western Oregon. Introduced from Europe.

2. CAPSELLA Medic.

1. *Capsella bursa-pastoris* (L.) Medic. Shepherd's purse.—East slope, yard of Smith Claim on Rock Creek. A very common weed. Introduced from Europe.

3. CAMELINA Crantz.

1. *Camelina microcarpa* Andrez. Hairy false flax.—East slope, yard of Smith Claim on Rock Creek. This species is found mainly in eastern Oregon but is sparingly introduced in western Oregon. Native of Europe.

4. BRASSICA L.

1. *Brassica campestris* L. Yellow mustard.—East slope growing in yard of Smith Claim on Rock Creek. An abundant weed introduced from Europe.

5. DESCURAINIA Webb & Barth.

1. *Descurainia pinnata* (Walt.) Britt. var. *filipes* (Gray) Peck. Tansy-mustard.—East slope, yard of Smith Claim on Rock Creek. Dry ground mainly in eastern Oregon. This species may be adventive in our region.

6. ERYSIMUM (Tourn.) L.

Annual; pods 1 mm wide ..... 1. *E. repandum*
Biennial; pods 2 mm wide ..... 2. *E. concinnum*

1. *Erysimum repandum* L. Bushy wallflower.—East slope, in yard of Smith Claim on Rock Creek. Very common in eastern Oregon, sparingly introduced in southern Oregon west of the Cascades. Introduced from Europe.

2. *Erysimum concinnum* Eastw. Coast wallflower.—South slope on Rogue River Divide. This species is a fairly common coastal wallflower in Curry County where it grows on hillsides and open slopes. It is a member of the California element in our flora.

7. DENTARIA L.

1. *Dentaria californica* Nutt. California toothwort.—Moist open hillsides on east slope along Coquille-Rogue River Divide. This species ranges from Mendocino County, California north to Coos County, Oregon. It represents the California element in the flora of our region. Transition.

8. STREPTANTHUS Nutt.

1. *Streptanthus tortuosus* Kell. var. *oblongus* Jeps. Twisted streptanthus.—Rock slides on east slope near summit. The first record of its occurrence north of the Rogue River in Coos County. Californian element. Canadian.

26. SARRACENIACEAE—Pitcher-plant Family

1. CHRYSAMPHORA Greene

1. *Chrysamphora californica* (Torr.) Greene. California pitcher-plant.—Very abundant at all stations on mountain in marshy and boggy ground. It occurs on the southwest slope at McCurdy Camp in a very large marsh and is common at Smith Claim on Rock Creek. It is a member of the California element in our flora ranging from northern California to Lane County, Oregon.

27. CRASSULACEAE—Stonecrop Family

1. SEDUM L.

Flowers yellow ..... 1. *S. spathulifolium*
Flowers pink or reddish ..... 2. *S. laxum*

1. *Sedum spathulifolium* Hook. Broad-leaved stonecrop.—Common on rocky outcrops and dry rock cliffs, east slope. Transition.

2. *Sedum laxum* (Britt.) Berger. Lax stonecrop.—High, dry, rocky ridges on south slope and on southeast slope along trail to Brushy Mountain. Ours is the first record of this plant growing north of the Rogue River. It is more common in southern Curry County. Canadian.

28. SAXIFRAGACEAE—Saxifrage Family

Herbs
  Stamens 5 or fewer
    Stamens 3 or 2; petals 4, linear; flowers purple ..... 1. *Tolmiea*
    Stamens 5
      Petals cleft, lobed or toothed ..... 2. *Mitella*

Petals entire
Placentae axial ..... 3. *Boykinia*
Placentae parietal or nearly basal ..... 4. *Heuchera*
Stamens 10
Placentae axial, ovary 2-loculed ..... 5. *Saxifraga*
Placentae parietal; ovary 1-loculed
Petals cleft, lobed or toothed ..... 6. *Tellima*
Petals entire, almost linear ..... 7. *Tiarella*
Shrubs
Leaves opposite ..... 8. *Whipplea*
Leaves alternate ..... 9. *Ribes*

1. TOLMIEA T. & G.

1. *Tolmiea menziesii* (Pursh) T. & G. Youth-on-age.—Along Rock Creek on east slope and at a spring near Smith Mine; not uncommon. Humid Transition and Canadian.

2. MITELLA L.

1. *Mitella ovalis* Greene. Small bishop's cap.—Along small creek on wooded southeast slope; common. Humid Transition.

3. BOYKINIA Nutt.

1. *Boykinia elata* (Nutt.) Greene. Slender boykinia.—East slope along banks of Rock Creek at Smith Claim; abundant. Humid Transition.

4. HEUCHERA L.

1. *Heuchera micrantha* Dougl. Small-flowered alum root.—Common on rock cliffs along Coquille-Rogue River Divide. Humid Transition.

5. SAXIFRAGA L.

Leaves orbicular to reniform; doubly dentate ..... 1. *S. mertensiana*
Leaves ovate to oblong, cuneate at the base, coarsely and evenly crenate ..... 2. *S. howellii*

1. *Saxifraga mertensiana* Bong. Merten's saxifrage.—South slope growing on mossy rocks along Boulder Creek in Bonanza Basin; very common. Canadian.

2. *Saxifraga howellii* Greene. Howell's saxifrage.—South slope, on wet mossy rocks along Boulder Creek in Bonanza Basin; quite common. A very rare and local species, its type locality is on the Coquille River in Oregon. Apparently limited to the Coquille and Rogue River watersheds in our region. A narrow endemic which has been rarely collected.

6. TELLIMA R. Br.

1. *Tellima grandiflora* (Pursh) Dougl. Fringe-cups.—Common on wet cliffs and hillsides near springs and water-courses on Coquille-Rogue River Divide. Humid Transition.

7. TIARELLA L.

Leaves simple, toothed ..... 1. *T. unifoliata*
Leaves compound, 3 leaflets ..... 2. *T. trifoliata*

1. *Tiarella unifoliata* Hook. Cool-wort.—East slope along Rock Creek at Smith Claim; abundant. Canadian.

2. *Tiarella trifoliata* L. Three-leaved cool-wort.—Growing along Rock Creek at Smith Claim on east slope; common. A representative of the Northern element in our flora, ranging from the coastal region of central Oregon northward to Alaska and into Asia. Ours is perhaps the extreme southern limit of its distribution.

9. RIBES L.

Stems without spines or prickles
- Flowers bell-shaped, rose-pink, showy ..... 1. *R. glutinosum*
- Flowers saucer-shaped, greenish, inconspicuous ..... 2. *R. bracteosum*

Stems bearing spines at the nodes ..... 3. *R. cruentum*

1. *Ribes glutinosum* Benth. Sticky currant.—South slope along Boulder Creek in Bonanza Basin, also common along Rock Creek and near summit on east slope. This species ranges into southern Oregon from California. It differs from *R. sanguineum* in having lighter colored flowers, and leaves without ventral tomentum. Humid Transition.

2. *Ribes bracteosum* Dougl. Stinking black currant.—East slope along Rock Creek below Smith Claim and south slope along banks of Boulder Creek in Bonanza Basin. Canadian.

3. *Ribes cruentum* Greene. Shiny-leaved gooseberry.—Open hillside along Middle Elk Road on Coquille-Rogue River Divide. Occurring on dry mountain ridges as far north as Lane County. This species represents the California element in our region.

29. ROSACEAE—Rose Family

Shrubs
- Fruits enclosed in an urn-shaped, globose receptacle ..... 1. *Rosa*
- Fruits not enclosed as above
  - Ovary inferior; fruit a pome ..... 2. *Amelanchier*
  - Ovary not inferior
    - Fruit dry, a follicle ..... 3. *Holodiscus*
    - Fruit fleshy, an aggregate of drupelets ..... 4. *Rubus*

Herbs ..... 5. *Horkelia*

1. ROSA L.

1. *Rosa gymnocarpa* Nutt. Wood rose.—Wooded hillsides along Rock Creek above Smith Claim on east slope; scattered. Transition and Canadian.

2. AMELANCHIER Medic.

1. *Amelanchier pallida* Greene. Pale serviceberry.—Growing at summit and also in thickets, east slope on hillside above Rock Creek; occasional. This is the first record of the plant from Coos County. It extends into our region from the Siskiyou Mountains where it is more common. Arid Transition.

3. HOLODISCUS Maxim.

1. *Holdiscus discolor* (Pursh) Maxim. Ocean spray.—Open hillsides on east and southwest slopes; common. Transition.

a. *Holodiscus discolor* (Pursh) Maxim. var. *delnortensis* Ley. Del Norte ocean spray.—Fairly common on dry rocky summits. This plant ranges from northern California to southern Oregon in the Siskiyou Mountains. The first record of its occurrence in the Rogue River Mountains. Canadian.

4. RUBUS L.

Stems creeping or trailing ..... 1. *R. vitifolius*
Stems erect
  Flowers red, rarely pinkish; fruit yellowish orange, rarely dark red ..... 2. *R. spectabilis*
  Flowers white
    Leaves simple, palmately lobed; fruit red ..... 3. *R. parviflorus*
    Leaves compound-pinnate; fruit black
      Leaflets usually 3, lanate beneath; stems hollow, very glaucous; fruit deciduous at maturity ..... 4. *R. leucodermis*
      Leaflets laciniate; stems not glaucous; fruit persistent at maturity ..... 5. *R. laciniatus*

1. *Rubus vitifolius* C. & S. Wild blackberry.—Common along Rock Creek and roadsides on Coquille-Rogue River Divide. Humid Transition.

2. *Rubus spectabilis* Pursh. Salmon-berry.—East slope along banks of Rock Creek; fairly common. Humid Transition and Coastal Canadian.

3. *Rubus parviflorus* Nutt. Thimbleberry.—Common along Rock Creek near Smith Claim. Humid Transition.

4. *Rubus leucodermis* Dougl. Western blackcap.—Along banks of Rock Creek on east slope and on hillsides Coquille-Rogue River Divide at junction of Middle Elk Road; common. Transition.

5. *Rubus laciniatus* Willd. Evergreen blackberry.—At Smith Mine on east slope. Common throughout western Oregon where it is an escape from cultivation.

5. HORKELIA C. & S.

1. *Horkelia sericata* S. Wats. Howell's horkelia.—Dry ridges and summits of the south slope; fairly common. It is known only from southwestern Oregon and adjacent California. Probably the northern limit for this species although it is common in Curry County farther south on high, dry ridges and sterile flats. The distribution of this species is very limited and it is thus a narrow endemic. Canadian.

30. LEGUMINOSAE—Pea Family

Leaves palmately compound
  Stamens all free ..... 1. *Thermopsis*
  Stamens not all free
    Leaflets 5 or more, entire ..... 2. *Lupinus*
    Leaflets 3 (in ours), not entire ..... 3. *Trifolium*
Leaves pinnately compound
  Foliage conspicuously glandular-dotted; leaves with only 3 leaflets ..... 4. *Psoralea*
  Foliage not glandular-dotted; leaves usually more than 3 leaflets (in ours)
    Tendrils none ..... 5. *Lotus*
    Tendrils usually present
      Style filiform, ending in a hairy, capitate stigma ..... 6. *Vicia*
      Style flattened, hairy only on the upper surface ..... 7. *Lathyrus*

1. THERMOPSIS R. Br.

1. *Thermopsis gracilis* How. Slender thermopsis.—South slope, on roadside cut and along Middle Elk Road on east slope, dry open hillsides; occasional. Humid Transition.

2. LUPINUS (Tourn.) L.

1. *Lupinus albicaulis* Dougl. White-stemmed lupine (fig. 11).—South and southwest slopes, in open woodlands; infrequent. Humid Transition.

3. TRIFOLIUM L.

Annual; involucre not deeply cleft; flowers light pink ..... 1. *T. microcephalum*
Perennial; involucre deeply cleft; flowers purple ..... 2. *T. wormskjoldii*

1. *Trifolium microcephalum* Pursh. Wooly clover.—Open rock slide along south slope; occasional. Transition.

2. *Trifolium wormskjoldii* Lehm. Marsh clover.—East slope, in yard of Smith Claim on Rock Creek. This is the common coastal clover in our region but it also occurs inland; not common. Humid Transition.—*T. involucratum* Ort.; *T. fimbriatum* Lindl.; *T. willdenovii* Spreng.

4. PSORALEA L.

1. *Psoralea physodes* Dougl. California tea.—Roadside along Middle Elk Road on Coquille-Rogue River Divide; infrequent. Humid Transition.

5. LOTUS L.

Annuals; flowers 1 or 2, axillary
  Calyx tube 1 mm long, teeth shorter than the tube; pods constricted between the seeds ..... 1. *L. micranthus*
  Calyx tube 1.5 to 2 mm long, teeth twice as long as the tube; pods not constricted ..... 2. *L. purshianus*
Perennials; flowers in umbels
  Flowers pinkish or purplish, 1 cm or more long; leaves nearly glabrous
    Stem strongly fistulose; leaves glaucous; flowers 8 to 30; peduncles shorter than the leaves ..... 3. *L. crassifolius*
    Stem not fistulose; leaves not glaucous; flowers 5 to 10; peduncles at least equal to the leaves ..... 4. *L. stipularis*
  Flowers yellowish, less than 1 cm long; leaves canescent ..... 5. *L. oblongifolius*

1. *Lotus micrantus* Benth. Slender trefoil.—In yard of Smith Claim along Rock Creek on east slope; fairly common. Humid Transition.

2. *Lotus purshianus* (Benth.) Clements & Clements. Spanish clover.—Southeast slope along Steffans Meadow trail, and on hillside in open woods along edge of Rock Creek below Smith Claim, east slope; common. Humid Transition.—*L. americanus* (Nutt.) Bisch.

3. *Lotus crassifolius* (Benth.) Greene. Pink trefoil.—Dry open woods of south slope; rare. This species barely reaches the state of Washington at its northern limit. It is more common southward into California. Arid Transition.

4. *Lotus stipularis* (Benth.) Greene var. *subglaber* Ottl. Thicket trefoil.—Open south slope and roadside banks above Rock Creek on east slope; very common. This trefoil is more common than the preceding species in our limits

and northward into Washington. It is often mistaken for *L. crassifolius*. Arid Transition.

5. *Lotus oblongifolius* Greene var. *torreyi* (Gray) Ottl. Torrey's trefoil. East slope in moist and marshy places along Rock Creek and its tributaries; common. This species represents the California element in our flora. It reaches its northern limit in Lane County. Canadian.

6. VICIA L.

1. *Vicia californica* Greene. California vetch.—East slope along Rock Creek at Smith Claim; common. This plant comes into Oregon from California and reaches its northern limit in southern Lane County. Arid Transition.

7. LATHYRUS L.

1. *Lathyrus vestitus* Nutt. Common Pacific Pea.—East slope along Rock Creek at lower end of Smith Claim. Quite common along watercourses. Our region is probably the northern limit of its range. Transition.

31. POLYGALACEAE—Milkwort Family

1. POLYGALA (Tourn.) L.

1. *Polygala californica* Nutt. California milkwort.—Thickets and dry hillsides on south and southwest slopes; scattered. Enters our limits from California. Probably as far north as this species ranges. Arid Transition.

32. ANACARDIACEAE—Cashew Family

1. RHUS L.

1. *Rhus diversiloba* T. & G. Poison oak.—Not common at this elevation but a small patch was noted on a rock slide, northwest slope. Humid Transition.

33. ACERACEAE—Maple Family

1. ACER L.

Leaves 7- to 9-lobed; wings of fruit spreading at right angles to the stalk 1. *A. circinatum*
Leaves 3- to 5-lobed; wings of fruit ascending 2. *A. glabrum*

1. *Acer circinatum* Pursh. Vine maple.—Hillside along Middle Elk Road on Coquille-Rogue River Divide; frequent. Humid Transition to Canadian.

2. *Acer glabrum* Torr. Dwarf maple.—Brushy hillsides below summit on north and east slopes; fairly common. Canadian.

34. RHAMNACEAE—Buckthorn Family

Flowers yellowish green; fruit berry-like 1. *Rhamnus*
Flowers blue or white; fruit a capsule 2. *Ceanothus*

1. RHAMNUS (Tourn.) L.

1. *Rhamnus californica* Esch. var. *occidentalis* How. Coffee berry.—Common ground cover on all open slopes and hillsides in this area. East slope along edge of wooded hillside, southeast slope and at summit. First time the

species has been reported from northern Curry and southern Coos counties. This may well be the northern limit of its range. Endemic to the Siskiyou and Rogue River Mountains. A representative of the California element. Arid Transition and Canadian.

2. CEANOTHUS L.

Tall erect shrub
- Leaves evergreen, varnished; flowers white ..... 1. *C. velutinus*
- Leaves deciduous; flowers usually bluish ..... 2. *C. integerrimus*

Prostrate shrub, forming mats ..... 3. *C. pumilus*

1. *Ceanothus velutinus* Dougl. var. *laevigatus* T. & G. Sticky laurel.—Dry southwest slope, forming dense thickets, usually at lower elevations than *C. pumilus*. Transition and Canadian.

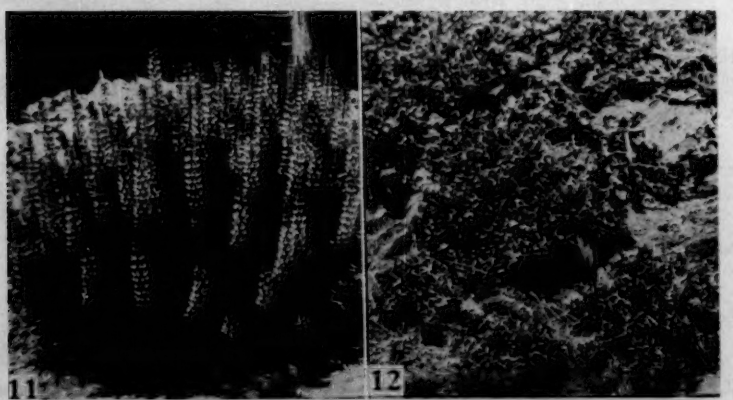
2. *Ceanothus integerrimus* H. & A. Deer brush.—South slope, forming thickets on hillsides and along roads; occasional. Transition.

3. *Ceanothus pumilus* Greene. Dwarf ceanothus.—South and southwest slopes up to summit, forming dense mats. Previously known only from the Siskiyou Mountains where it apparently supplants *C. prostratus*, and is a narrow endemic. The type locality is "On hillsides near Waldo, Oregon, April 1892. Thomas Howell." Upper Transition and Canadian.

35. MALVACEAE—Mallow Family

1. SIDALCEA Gray

1. *Sidalcea malvaeflora* (DC.) A. Gray. Checkerbloom.—Roadside along Middle Elk Road on Coquille-Rogue River Divide and on east slope along Rock Creek below Smith Claim; quite common. This plant is a coastal species that comes into our area. It occurs from California northward to Curry and Coos counties, and is considered to be a representative of the California element in the flora of our region. Transition.



Figs. 11-12.—11. *Lupinus albicaulis*, southeast slope growing in the Middle Elk Road. 12. A prostrate shrub, *Ceanothus pumilus*, east slope.

36. HYPERICACEAE—St. John's Wort Family

1. HYPERICUM (Tourn.) L.

1. *Hypericum perforatum* L. St. John's wort.—Roadside Middle Elk Road along Coquille-Rogue River Divide; common. Introduced from Europe. A noxious weed.

37. VIOLACEAE—Violet Family

1. VIOLA L.

Stem creeping and prostrate; leaves evergreen ..... 1. *V. sempervirens*
Stem not creeping, erect; leaves not evergreen
  Flowers yellow; leaves cordate ..... 2. *V. glabella*
  Flowers purple and white; leaves cuneate ..... 3. *V. cuneata*

1. *Viola sempervirens* Greene. Evergreen violet.—Southwest slope at McCurdy Camp; common. Humid Transition.

2. *Viola glabella* Nutt. Wood violet.—East slope along Rock Creek at Smith Claim; fairly common. Canadian.

3. *Viola cuneata* S. Wats. Wedge-leaved violet.—Dry open woods and thickets on south and southwest slope up to summit; common. This violet is found only in the mountains of Coos, Curry and Josephine counties in Oregon and in the northern counties of California. Our record is the first one for Coos County and the Rogue River Mountains. Transition.

38. ONAGRACEAE—Evening Primrose Family

1. EPILOBIUM L.

Flowers showy; petals spreading, 15-18 mm long, entire ..... 1. *E. angustifolium*
Flowers small; petals not spreading, 3-10 mm long, cleft
  Annuals; stigma 4-cleft
    Herbage nearly glabrous; petals 5-7 mm long ..... 2. *E. paniculatum*
    Herbage crisped puberulent; petals 3-4 mm long ..... 3. *E. minutum*
  Perennials; stigma entire; plants 3-9 dm tall ..... 4. *E. adenocaulon*

1. *Epilobium angustifolium* L. Fireweed.—Common on east slope along Rock Creek at Smith Claim. Transition to Canadian.

2. *Epilobium paniculatum* Nutt. Tall willow herb.—East slope along roadside at Smith Claim on Rock Creek; quite common. Transition.

3. *Epilobium minutum* Lindl. Small-flowered willow herb.—East slope, on roadside bank along edge of Rock Creek above Smith Claim; very common. Transition.

4. *Epilobium adenocaulon* Hausskn. Common willow herb.—East slope, roadside ditch near spring, moist ground; not common. Transition.

39. ARALIACEAE—Ginseng Family

1. ARALIA L.

1. *Aralia californica* S. Wats. California spikenard.—Along Middle Elk Road on Coquille-Rogue River Divide; occasional. Transition. Ranges from southern California to Coos and Curry counties in Oregon. A species of the California element in our flora.

40. UMBELLIFERAE—Parsley Family

Flowers yellow ..... 1. *Lomatium*
Flowers white
  Fruits winged, strongly flattened dorsally
    Low plants; leaves basal ..... 1. *Lomatium*
    Tall plants; cauline leaves present ..... 2. *Angelica*
  Fruits not winged; not flattened dorsally
    Leaflets linear, few ..... 3. *Perideridia*
    Leaflets broader, ternate, deeply incised ..... 4. *Ligusticum*

1. LOMATIUM Raf.

Flowers white ..... 1. *L. macrocarpum*
Flowers yellow
  Leaves triternate; mature fruit about 10 mm long; wings narrower than the body ..... 2. *L. triternatum*
  Leaves bipinnate; mature fruit about 15 mm long; wings as wide as the body ..... 3. *L. martindalei*

1. *Lomatium macrocarpum* (H. & A.) C. & R. Gray hog fennel.—Common on high dry rocky ridges and slopes from 3700 to 4000 feet. This species is infrequent west of the Cascades, but is common to the east of our region.

2. *Lomatium triternatum* (Pursh) C. & R. Narrow-leaved hog fennel.—On north and south slopes near summit. Canadian.

3. *Lomatium martindalei* C. & R. Martindale's hog fennel.—Along south slope and at summit. This plant occurs in the high Cascades and on the summits of peaks in the Coast Range. Apparently limited to southern Oregon. Canadian to Hudsonian.

2. ANGELICA L.

1. *Angelica arguta* Nutt. Shining angelica.—East slope, thickets along Rock Creek at Smith Claim. This species ranges from British Columbia as far south as northern California. It is a representative of the Northern element in our flora.

3. PERIDERIDIA Reichb.

1. *Perideridia oregana* (Wats.) Math. Oregon false caraway.—Southwest slope along Steffans Meadow trail and growing in dry meadows on south slope; abundant. Transition.—*Carum oreganum* Wats.

4. LIGUSTICUM L.

1. *Ligusticum apiifolium* (Nutt.) Gray. Celery-leaved lovage.—South slope and along Rock Creek at Smith Claim on east slope. This species ranges as far south as central California. Humid Transition.

41. GARRYACEAE—Silk Tassel Family

1. GARRYA Dougl.

1. *Garrya buxifolia* A. Gray. Box-leaved garrya.—West slope near summit and south slope on dry open hillside. This is the northern known limit for this plant. It is most abundant in the Siskiyou Mountains and ranges southward to Mendocino County, California.

42. CORNACEAE—Dogwood Family

1. CORNUS L.

1. *Cornus nuttallii* Aud. Western flowering dogwood.—Common on east slope just below summit, also one tree growing on a hillside at junction of Middle Elk Road, Coquille-Rogue River Divide. Humid Transition to Canadian in our region.

43. ERICACEAE—Heath Family

Ovary superior
- Herbs or sometimes shrubby at base
  - Plants with green leaves
    - Flowers in corymbs or umbels; filaments dilated at or below the middle ..... 1. *Chimaphila*
    - Flowers in racemes; filaments not dilated ..... 2. *Pyrola*
  - Plants without green leaves
    - Style conspicuously long-exserted ..... 2. *Pyrola*
    - Style not long-exserted
      - Petals none; plant red and white striped ..... 3. *Allotropa*
      - Petals present
        - Petals distinct, nearly to the base
          - Plant yellowish; ovary 4 to 5 loculed ..... 4. *Hypopitys*
          - Plant whitish; ovary 1 loculed ..... 5. *Pleuriscospora*
        - Petals united, almost to the tip
          - Plant reddish; ovary 4 to 5 loculed ..... 6. *Pterospora*
          - Plant white; ovary 1 loculed ..... 7. *Hemitomes*
- Shrubs or trees
  - Shrubs
    - Petals distinct ..... 8. *Ledum*
    - Petals united
      - Flowers large, very showy, over 2 cm ..... 9. *Rhododendron*
      - Flowers small, under 1 cm
        - Calyx becoming enlarged and fleshy; bark not reddish ..... 10. *Gaultheria*
        - Calyx small and dry; bark red ..... 11. *Arctostaphylos*
  - Trees ..... 12. *Arbutus*

Ovary inferior ..... 13. *Vaccinium*

1. CHIMAPHILA Pursh

Leaves wider above the middle ..... 1. *C. umbellata*
Leaves wider below the middle ..... 2. *C. menziesii*

1. *Chimaphila umbellata* Nutt. var. *occidentalis* (Rydb.) Blake. Western prince's pine.—East and south slopes, in dense shady woods, also on west slope nearly up to summit; common. Canadian.

2. *Chimaphila menziesii* (R. Br.) Spreng. Menzies' prince pine.—Woods along trail on south slope; infrequent. Canadian.

2. PYROLA L.

Plants with green leaves
- Style straight, erect; flowers in a one-sided raceme ..... 1. *P. secunda*
- Style curved downward; flowers not as above
  - Flowers red or pinkish ..... 2. *P. bracteata*
  - Flowers yellowish white
    - Leaves white-veined, elliptic to ovate ..... 3. *P. picta*

Leaves green or only very slightly white-veined, lanceolate to oblanceolate ..... 4. *P. dentata*

Plants with leaves reduced to bracts only
Flowers red or pinkish ..... 5. *P. aphylla*
Flowers yellowish white ..... 4. *P. dentata*

1. *Pyrola secunda* L. One-sided wintergreen.—Open woods on south slope; not common. Canadian.

2. *Pyrola bracteata* Hook. Leathery shin-leaf.—Woods of south and southwest slopes; quite common. Our area is near the southern boundary of the range of this species. It is found growing northward as far as British Columbia. Canadian.

3. *Pyrola picta* Smith. White-veined shin-leaf.—Dry open coniferous woods of south slope; very common. Canadian.

4. *Pyrola dentata* Smith. Toothed shin-leaf.—Southwest slope, in woods near Boulder Creek on Parker Claim, also on east slope at spring below lookout station; very common. Canadian.

a. *Pyrola dentata* Smith var. *integra* A. Gray. Entire-leaved shin-leaf.—Hillside above Middle Elk Road on the Coquille-Rogue River Divide; fairly rare. This plant differs from the above in having entire leaves, or sometimes the leaves are reduced or even wanting, suggesting *P. aphylla* with yellowish-white flowers. Canadian.

5. *Pyrola aphylla* Smith. Leafless wintergreen.—Open woods of south and southwest slopes; occasional. This species has a very wide distribution but is apparently never abundant. Canadian.

3. ALLOTROPA T. & G.

1. *Allotropa virgata* T. & G. Barber pole.—Coniferous woods on south and southeast slopes; occasional. This plant grows in colonies. Canadian.

4. HYPOPITYS Adans.

Leaves entire or only slightly erose ..... 1. *H. lanuginosa*
Leaves distinctly erose, the upper fimbriate ..... 2. *H. fimbriata*

1. *Hypopitys lanuginosa* (Michx.) Nutt. Broad-leaved pinesap.—Coniferous woods on southeast slope and on south slope along trail to summit; rare. This species reaches northwestern California. It is a plant of the northern element and the northern hemisphere. Canadian.

2. *Hypopitys fimbriata* (A. Gray) How. Fringed pinesap.—Open coniferous woods on south and east slopes; rare. A plant of the Southern element. It has not been recorded from the state of Washington.

5. PLEURICOSPORA A. Gray

1. *Pleuricospora fimbriolata* A. Gray. Fimbriate pinesap.—Coniferous woods of the south slope; rare. Canadian.

6. PTEROSPORA Nutt.

1. *Pterospora andromedia* Nutt. Pinedrops.—Dry coniferous woods on

west slope near summit; rare. The plant grows in colonies and dies after flowering. Canadian.

7. HEMITOMES A. Gray

1. *Hemitomes congestum* A. Gray. Hemitomes.—South slope along Steffans Meadow trail. Rare in dense coniferous woods. This plant is not often collected. It forms large colonies in locations where it occurs. Canadian.

8. LEDUM L.

1. *Ledum columbianum* Piper. Labrador tea.—Common in marshes on east slope and on southwest slope at McCurdy Camp. It is found in locations that are quite boggy growing with *Chrysamphora californica*. Humid Transition and Canadian.

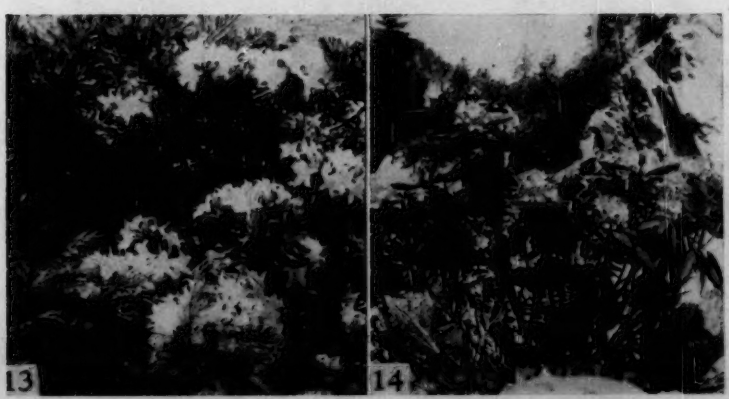
9. RHODODENDRON L.

Flowers white or pink; stamens 5 ..... 1. *R. occidentale*
Flowers rose-purple, except in forma *album*: stamens 10 ..... 2. *R. macrophyllum*

1. *Rhododendron occidentale* (T. & G.) Gray. Western azalea (fig. 13).—Southwest slope at McCurdy Camp and on south slope. Also quite common along banks of Rock Creek above Smith Claim. This beautiful shrub occurs as far north as the mouth of the Umpqua River along the coast. It grows farther inland as its range extends southward. Humid Transition.

2. *Rhododendron macrophyllum* G. Don. Rhododendron (fig. 14).—This is one of the commonest shrubs at upper elevations. East and south slopes almost to summit and on southwest slope at McCurdy Camp. Humid Transition to Canadian.

a. *Rhododendron macrophyllum* G. Don. forma *album* Rehder. White rhododendron.—Southwest slope. This rare and beautiful form of which only one plant has been found on the mountain, is well worth cultivation. Canadian.



Figs. 13-14.—13. *Rhododendron occidentale*, Middle Elk Road, southwest slope at McCurdy Camp junction. 14. *Rhododendron macrophyllum*, east slope on Rock Creek at Smith Claim.

10. GAULTHERIA L.

Leaves 3 cm or less long; fruit scarlet ..... 1. *G. ovatifolia*
Leaves 5 to 12 cm long; fruit black ..... 2. *G. shallon*

1. *Gaultheria ovatifolia* A. Gray. Slender gaultheria.—Southwest slope on saddle between Iron Mountain and Ranger Peak, open west slope nearly to summit and open woods on south slope. Reaches its southern limit in the Siskiyou Mountains. Canadian.

2. *Gaultheria shallon* Pursh. Salal.—Woods on east slope above Smith Claim and on west slope; very common. Humid Transition.

11. ARCTOSTAPHYLOS Adans.

Low matted or creeping shrubs ..... 1. *A. nevadensis*
Erect bushy shrubs
  Young twigs with coarse blackish glandular hairs ..... 2. *A. columbiana*
  Young twigs without black glandular hairs
    Branchlets glandular
      Leaves dense, over twice as long as wide ..... 3. *A. hispidula*
      Leaves not dense, about twice as long as wide ..... 4. *A. patula*
    Branchlets not glandular ..... 5. *A. canescens*

1. *Arctostaphylos nevadensis* A. Gray. Pine-mat manzanita.—West slope near summit, also on south slope in open coniferous woods; fairly common. This species occurs near the coast in Curry County. Canadian.

2. *Arctostaphylos columbiana* Piper. Columbia manzanita.—Brushy hillsides on south slope; common. This would appear to be the most widespread manzanita in our region. Humid Transition.

3. *Arctostaphylos hispidula* Howell. Howell's manzanita.—Dry open woods on south slope; rare. Occurs in the Siskiyou Mountains of southern Oregon and northern California, also on dry rocky summits in the Rogue River Mountains of Curry County. Canadian.

4. *Arctostaphylos patula* Greene. Green-leaved manzanita.—Dry open hillside on south slope; occasional patches. Has a very wide range but is not abundant in our area. Canadian.

5. *Arctostaphylos canescens* Eastw. Hoary manzanita.—West slope near summit; fairly common. Ranges from Douglas County southward to California, overlapping with *A. columbiana* in this region. Humid Transition.

12. ARBUTUS L.

1. *Arbutus menziesii* Pursh. Madroño.—Hillside southwest slope and along Middle Elk Road on Coquille-Rogue River Divide; occasional. Humid Transition.

13. VACCINIUM L.

Leaves evergreen ..... 1. *V. ovatum*
Leaves not evergreen
  Leaves entire except on young growth, berry bright red ..... 2. *V. parvifolium*
  Leaves sharply serrate; berry dark red to black ..... 3. *V. membranaceum*

1. *Vaccinium ovatum* Pursh. Evergreen huckleberry.—Common on southwest slope, forming thickets. Canadian.

2. *Vaccinium parvifolium* Smith. Red huckleberry.—Very common on all slopes nearly to summit. Our most abundant huckleberry. Canadian.

3. *Vaccinium membranaceum* Dougl. Mountain huckleberry.—Abundant on north slope below summit, and the only station recorded. Not previously known from the coastal mountains in Oregon, though it is common in the Cascade and Siskiyou ranges. Apparently the first record for the Rogue River Mountains. Canadian.

44. PRIMULACEAE—Primrose Family

1. TRIENTALIS L.

Leaves acute, clustered at summit of stem ..... 1. *T. latifolia*
Leaves obtuse, scattered along stem or both scattered and clustered ..... 2. *T. arctica*

1. *Trientalis latifolia* Hook. Broad-leaved star-flower.—Open woods on south slope, roadside marshes and along banks of Rock Creek on east slope; fairly common. Widely distributed. Canadian.

2. *Trientalis arctica* Fisch. Northern star-flower.—East slope along Rock Creek, in wet boggy ground with *Chrysamphora californica*. Representative of the Northern element and probably reaches its southern limit in Curry County.

45. GENTIANACEAE—Gentian Family

1. GENTIANA L.

1. *Gentiana sceptrum* Griseb. King's gentian.—Bogs, east slope along roadside near summit, also west slope and southwest slope at McCurdy Camp. Principally a coastal bog species. First record for the Rogue River Mountains. Canadian here.

46. APOCYNACEAE—Dogbane Family

1. APOCYNUM L.

1. *Apocynum androsaemifolium* L. Dogbane.—Open brushy west and southwest slopes near summit; not common. A species of wide distribution. Transition to Canadian.

47. CONVOLVULACEAE—Morning-glory Family

1. CONVOLVULUS

1. *Convolvulus polymorphus* Greene. Pale morning-glory.—East slope above Smith Claim and along Middle Elk Road on Coquille-Rogue River Divide; rare. This species enters our limits from northern California and has a rather spotty distribution in Oregon. It is common along the Rogue River between Agness and Illahe, is reported from Deschutes Canyon at Maupin, Wasco County, and the writer has collected it in the Warner Mountains, Lake County, Oregon. Arid Transition.

48. POLEMONIACEAE—Phlox Family

Perennial; corolla 15 to 20 mm wide ..... 1. *Phlox*
Annual; corolla 5 to 8 mm wide ..... 2. *Collomia*

1. PHLOX L.

1. *Phlox diffusa* Benth var. *longistylis* (Wher.) Peck. Mountain phlox. —Open coniferous woods on southeast slope and on east slope near summit; occasional. This is the common phlox of the high Cascade Mountains from Lane County northward and is the southernmost record in the Coast Range. It probably intergrades into typical *Phlox diffusa* southward in the Siskiyou Mountains, intermediate regions must be studied more intensively, since the range of the numerous varieties is too imperfectly known. Canadian.

2. COLLOMIA Nutt.

1. *Collomia heterophylla* Hook. Vari-leaved collomia.—Hillside above Middle Elk Road on east slope, open woods; common. Humid Transition.

49. HYDROPHYLLACEAE—Water-leaf Family

1. PHACELIA Juss.

1. *Phacelia corymbosa* Jepson. Serpentine phacelia.—Dry open hillside on south slope; occasional. The distribution of this northern California plant in Oregon is not well known. Ours is probably the most northern record which has been obtained to date.

50. BORAGINACEAE—Borage Family

1. CRYPTANTHA Lehm.

1. *Cryptantha Hendersoni* (Nels.) Piper. Large-flowered cryptantha.—East slope, yard of Smith Claim on Rock Creek; not common. Transition.

51. LABIATAE—Mint Family

Nutlets distinctly united below, attached on the inside; stamens long exserted, curved ..... 1. *Trichostema*

Nutlets almost separate; attached at the base; stamens not as above

Calyx teeth conspicuously unequal ..... 2. *Prunella*

Calyx teeth nearly equal

Plants creeping; flowers axillary ..... 3. *Satureja*

Plants erect; flowers in dense terminal heads ..... 4. *Monardella*

1. TRICHOSTEMA L.

1. *Trichostema lanceolatum* Benth. Vinegar weed.—Dry open hillsides on south slope, covering large areas in open grassy meadows. Arid Transition.

2. PRUNELLA L.

1. *Prunella vulgaris* L. Heal-all.—Moist ground along Rock Creek at Smith Claim on east slope; common. Introduced from Europe.

3. SATUREJA L.

1. *Satureja douglasii* (Benth.) Briq. Oregon tea.—Southwest slope along Steffans Meadow trail. Transition.

4. MONARDELLA Benth.

1. *Monardella villosa* Benth. var. *subserrata* (Greene) Epl. Coyote mint. —East slope on summit of the Coquille-Rogue River Divide. Known as far

north as the Umpqua River Valley; quite common in the Rogue River Valley to the south of Iron Mountain. Transition.

52. SCROPHULARIACEAE—Figwort Family

Upper lip of the corolla helmet-shaped ..... 6. *Castilleja*
Upper lip of the corolla not helmet-shaped
  Corolla nearly regular
    Anther bearing stamens 5 ..... 1. *Verbascum*
    Anther bearing stamens 2
      Corolla rotate; leaves opposite, all cauline ..... 4. *Veronica*
      Corolla campanulate; leaves mostly basal; the few cauline leaves alternate ..... 5. *Synthyris*
  Corolla irregular, strongly 2-lipped; stamens 4 or, 5 with one sterile
    Stamens 5, one sterile ..... 2. *Penstemon*
    Stamens 4, all fertile ..... 3. *Mimulus*

1. VERBASCUM L.

1. *Verbascum blattaria* L. Moth mullein.—Open meadow on southwest slope along the Steffans Meadow trail; quite common. Introduced from Europe.

2. PENSTEMON Mitch.

Flowers rose-pink to reddish ..... 1. *P. rupicola*
Flowers lavender to bluish ..... 2. *P. rattanii*

1. *Penstemon rupicola* How. Crimson penstemon.—Rocky point on south slope, also on west slope and at summit. This species has previously been known only from the Cascades. A first record for the Coast Mountains, and it has not been reported from the Siskiyou Mountains, although the writer has collected it on high mountain peaks as far south as Snow Camp Mountain in central Curry County. Canadian.

2. *Penstemon rattanii* A. Gray. Rattan's penstemon.—Open south slope on gravelly hillside and on east slope along the Middle Elk Road, Coquille-Rogue River Divide; occasional colonies. This species does not range much farther north than our region, but is not uncommon in the southern Coast Mountains. The writer has collected it on Snow Camp Mountain in central Curry County. Canadian.

3. MIMULUS L.

Annual; corolla 8 to 12 mm long, purple spot in the middle of lower lip ..... 1. *M. alsinoides*
Perennial; corolla 1.5 to 2 cm long, purple spot not present ..... 2. *M. moschatus*

1. *Mimulus alsinoides* Dougl. Baby monkey-flower.—East slope, on face of moist cliff; not common. Canadian here.

2. *Mimulus moschatus* Dougl. Musk flower.—East slope, in roadside ditch and along Rock Creek at Smith Claim; widespread in wet places. Transition.

4. VERONICA L.

1. *Veronica americana* Schwein. Common speedwell.—Moist ground along slow running streams on south slope; common. Transition.

5. SYNTHYRIS Benth.

1. *Synthyris reniformis* (Dougl.) Benth. var. *cordata* A. Gray. Spring queen.—This plant is very different in appearance from typical *S. reniformis*. It has unusually long leaves, in many cases twice as long as wide. The flowers in general are larger and more showy and a much deeper blue. This variety is the only one found in our area and it ranges from northern California to Josephine, Curry and Douglas counties in Oregon. Not previously collected from the Rogue River Mountains. Humid Transition to Canadian.

6. CASTILLEJA Mutis.

1. *Castilleja pruinosa* Fern. Frosted paintbrush.—Common on all slopes, nearly to summit. Ranges into Curry County from California and occurs only as far north as Mount Jefferson in the Cascades.

53. OROBANCHACEAE—Broom-rape Family

Base of the stamen filament with a tuft of hairs; flowers numerous, borne on a cone-like spike ..... 1. *Boschniakia*

Base of the stamen filament not hairy; flowers solitary on long slender peduncles ..... 2. *Orobanche*

1. BOSCHNIAKIA C. A. Mey.

1. *Boschniakia strobilacea* A. Gray. Ground-cone.—Along Steffans Meadow trail growing in pure stand of *Arbutus menziesii*, also near summit, on roots of *Arctostaphylos canescens*. This species is found in southern Oregon and adjacent California. Humid Transition to Canadian.

2. OROBANCHE L.

1. *Orobanche uniflora* L. Broom-rape.—East slope on moist cliff; rare. Only one plant was found. This species has a wide distribution but is not common. Canadian here.

54. PLANTAGINACEAE—Plaintain Family

1. PLANTAGO L.

Leaves long-lanceolate ..... 1. *P. lanceolata*

Leaves broadly ovate ..... 2. *P. major*

1. *Plantago lanceolata* L. English plantain.—East slope along Rock Creek at Smith Claim; common. Introduced from Europe.

2. *Plantago major* L. Common plantain.—East slope in the yard at Smith Claim; common. Introduced from Europe.

55. RUBIACEAE—Madder Family

1. GALIUM L.

Leaves mostly 6 to a whorl ..... 1. *G. triflorum*

Leaves 4 to a whorl ..... 2. *G. bolanderi*

1. *Galium triflorum* Michx. Fragrant bed-straw.—East slope at roadside marsh and along Rock Creek at Smith Claim; quite common. Transition.

2. *Galium bolanderi* A. Gray. Bolander's bed-straw.—South slope along

Steffans Meadow trail and east slope in woods along Rock Creek; common. This is an extension of the range of this plant northward. Transition.

56. CAPRIFOLIACEAE—Honeysuckle Family

Leaves simple
  Shrubs, erect or climbing
    Flowers irregular; fruit a red berry ..... 1. *Lonicera*
    Flowers regular; fruit a white berry ..... 2. *Symphoricarpos*
  Vine, prostrate or creeping; flowers in pairs ..... 3. *Linnaea*
Leaves compound ..... 4. *Sambucus*

1. LONICERA L.

1. *Lonicera hispidula* (Lindl.) T. & G. Pink honeysuckle.—On hillside along Middle Elk Road, Coquille-Rogue River Divide; not common. The species ranges from the Rogue River Valley north to Washington. Several varieties of this species are recorded from southern Oregon, south into the coast ranges of California. Humid Transition.

2. SYMPHORICARPOS L.

1. *Symphoricarpos acutus* (Gray) Diek. Creeping snowberry.—Along roadside on Middle Elk Road, Coquille-Rogue River Divide; occasional. Transition.

3. LINNAEA L.

1. *Linnaea borealis* L. var. *americana* (Forbes) Rehder.—Open woods on south slope and along Rock Creek at Smith Claim on east slope. Humid Transition and Canadian.

4. SAMBUCUS L.

1. *Sambucus coerulea* Raf. Blue elderberry.—Along Middle Elk Road on Coquille-Rogue River Divide, forming thickets; not common. Transition.—*S. glauca* Nutt.

57. VALERIANACEAE—Valerian Family

1. VALERIANA L.

1. *Valeriana sitchensis* Bong. Mountain valerian.—South slope growing on moist banks; common. Canadian.

58. CAMPANULACEAE—Bell-flower Family

1. CAMPANULA L.

Flowers dark blue; leaves nearly sessile ..... 1. *C. prenanthoides*
Flowers pale blue; leaves petioled ..... 2. *C. scouleri*

1. *Campanula prenanthoides* Durand. Slender blue-bell.—East slope along road to summit and along Middle Elk Road, also on dry open hillsides; very common. This species is of California origin. It is known only as far north as west central Oregon. Humid Transition.

2. *Campanula scouleri* Hook. Pale blue-bell.—Common on hillsides in dry woods on east slope along Middle Elk Road. Humid Transition to Canadian.

59. COMPOSITAE—Sunflower Family

Flowers all strap shaped; juice milky
- Pappus plumose ..... 1. *Hypochaeris*
- Pappus bristles not plumose
  - Heads solitary; leaves all basal ..... 2. *Agoseris*
  - Heads several; cauline leaves present ..... 3. *Hieracium*

Flowers all tubular or heads composed of both tubular and strap-shaped flowers
- Heads with both strap-shaped and tubular flowers present
  - Pappus of hairs or bristles
    - Leaves opposite ..... 18. *Arnica*
    - Leaves alternate
      - Ray flowers yellow ..... 19. *Senecio*
      - Ray flowers purple, bluish, pinkish or white (ours)
        - Involucre bracts in one series; basal leaves very large, not appearing at flowering time, stem leaves bract-like ..... 16. *Petasites*
        - Involucre bracts not in one series; leaves normal
          - Involucre bract narrow, usually in an even series, sometimes two; rays narrow, numerous ..... 5. *Erigeron*
          - Involucre bracts in several series, broader, generally overlapping the rays, fewer than above
            - Disk-flowers yellow ..... 4. *Aster*
            - Disk-flowers white to purple ..... 6. *Sericocarpus*
  - Pappus with few scales, or awns or none
    - Ligules yellow
      - Pappus crown-like, of short chaffy teeth ..... 12. *Wyethia*
      - Pappus not of chaffy teeth
        - Bracts of the involucre enfolding the outer achenes ..... 13. *Madia*
        - Bracts not enfolding the achenes
          - Heads cone-shaped; disk-flowers intermingled with conspicuous short chaffy bracts ..... 11. *Rudbeckia*
          - Heads not cone-shaped; disk-flowers without intermingled chaffy bracts ..... 14. *Eriophyllum*
    - Ligules white (ours) ..... 15. *Chrysanthemum*
- Heads with flowers all tubular
  - Pappus of hairs or bristles
    - Flowers purple or whitish
      - Leaves prickly; flowers purplish ..... 20. *Cirsium*
      - Leaves not prickly; flowers whitish
        - Involucre bracts equal, one series ..... 17. *Luina*
        - Involucre bracts not equal, in several series
          - Dioecious
            - Pappus bristles of the staminate flowers club-shaped ..... 7. *Antennaria*
            - Pappus bristles all alike, not as above ..... 8. *Anaphalis*
          - Monoecious ..... 9. *Gnaphalium*
    - Flowers bright yellow
      - Leaves opposite ..... 18. *Arnica*
      - Leaves alternate ..... 19. *Senecio*
  - Pappus none; flowers white ..... 10. *Adenocaulon*

1. HYPOCHAERIS L.

1. *Hypochaeris radicata* L. False dandelion.—Roadside weed on east slope along Rock Creek. Introduced from Europe.

2. AGOSERIS Raf.

1. *Agoseris laciniata* (Nutt.) Greene. Tall false dandelion.—Dry open hillside on south slope; not common. Humid Transition.

3. HIERACIUM L.

Flowers white ..... 1. *H. albiflorum*
Flowers yellow
Involucre copiously glandular-pubescent, bracts narrowly linear ..... 2. *H. cynoglossoides*
Involucre glabrous, or nearly so; bracts broadly linear, obtuse or acute .... 3. *H. bolanderi*

1. *Hieracium albiflorum* Hook. White-flowered hawkweed.—East slope, open woods and roadsides along Rock Creek and fairly common in open woods. Transition.

2. *Hieracium cynoglossoides* Arv.-Touv. Houndstongue hawkweed.—South slope on dry ridges and in open woods. Canadian.

3. *Hieracium bolanderi* Gray. Bolander's Hawkweed.—Dry hillsides on east slope. The first record of this plant as far north as Coos County. Common in Josephine County, and southward into California. Transition.

4. ASTER L.

1. *Aster radulinus* Gray. Rough-leaved aster.—Hillside along Middle Elk Road on Coquille-Rogue River Divide; common. Transition.

5. ERIGERON L.

1. *Erigeron foliosus* Nutt. var. *confinis* (How.) Jepson. Leafy daisy.—West and south slopes below summit, in open coniferous woods; scattered. This species ranges from Mt. Jefferson in Oregon to the Trinity Mountains of California. At the summit of the mountain is found the low hairy form considered by Cronquist (1947) to belong to the above species and variety.

6. SERICOCARPUS Nees.

1. *Sericocarpus rigidus* Lindl. Rigid white-topped aster.—Hillside along Middle Elk Road, Coquille-Rogue River Divide. Transition.

7. ANTENNARIA Gaertn.

Heads solitary; stems shrubby ..... 1. *A. suffrutescens*
Heads several in a cluster; not shrubby ..... 2. *A. rosea*

1. *Antennaria suffrutescens* Greene. Shrubby everlasting.—Dry open hillside on south slope; common. Found only in southwestern Oregon. Previously reported only from Josephine County. Canadian.

2. *Antennaria rosea* Greene. Rosy everlasting.—Found only at one station on summit. The first record from the Rogue River Mountains. It has been previously collected in the Siskiyou Mountains. Canadian.

8. ANAPHALIS DC.

1. *Anaphalis margaritacea* (L.) A. Gray. Pearly everlasting.—East slope along road at Smith Claim, also on dry open hillsides; very common. Canadian.

9. GNAPHALIUM L.

1. *Gnaphalium microcephalum* Nutt. var. *thermale* (E. Nels.) Cron. Slender cudweed.—Common on dry open ground along Middle Elk Road, Coquille-Rogue River Divide. Transition.

10. ADENOCAULON Hook.

1. *Adenocaulon bicolor* Hook. Pathfinder.—Woods along trail on south slope and in roadside marsh below Smith Claim on Rock Creek, east slope; common. Humid Transition to Canadian.

11. RUDBECKIA L.

1. *Rudbeckia californica* Gray. California coneflower.—East slope on hillsides in marshy and boggy ground, also west slope in wet places about springs. Canadian here. This species represents the California element in our flora, and extends northward to the Umpqua River Valley.

12. WYETHIA Nutt.

1. *Wyethia angustifolia* (DC.) Nutt. Mule-ears.—Dry open hillsides on southeast slope; not common. Transition.

13. MADIA Molina.

Perennial ..... 1. *M. madioides*
Annuals
Heads small, 3 to 4 mm broad ..... 2. *M. exigua*
Heads larger; 5 to 7 mm broad ..... 3. *M. gracilis*

1. *Madia madioides* (Nutt.) Greene. Woodland tarweed.—Woods on southeast slope; common. Humid Transition.

2. *Madia exigua* (Smith) Gray. Little tarweed.—Dry ground along trails, roadsides and in open woods; common along Middle Elk Road on Coquille-Rogue River Divide. Transition.

3. *Madia gracilis* (Smith) Keck. Common tarweed.—Along Middle Elk Road on Coquille-Rogue River Divide. Canadian.—*M. dissitiflora* (Nutt.) T. & G.

14. ERIOPHYLLUM Lag.

1. *Eriophyllum lanatum* (Pursh) Forbes var. *achillaeoides* (DC.) Jepson. Oregon sunshine.—South slope along Middle Elk Road on Coquille-Rogue River Divide; common. Transition.

15. CHRYSANTHEMUM Lag.

1. *Chrysanthemum leucanthemum* L. Ox-eye daisy.—Roadside along Middle Elk Road on Coquille-Rogue River Divide; occasional. Introduced from Europe.

16. PETASITES (Tourn.) Hill

1. *Petasites palmatus* (Ait.) Gray. Western coltsfoot.—East slope along Rock Creek at Smith Claim and south slope along Boulder Creek in Bonanza Basin. Humid Transition.

17. LUINA Benth.

1. *Luina hypoleuca* Benth. Silver-back.—Rocks and cliffs at summit. Canadian.

18. ARNICA L.

Ray flowers none
- Basal leaves distinctly petiolate, scarcely winged ..... 1. *A. parviflora*
- Basal leaves appearing sessile, petioles broadly winged ..... 2. *A. spathulata*

Ray flowers present
- Basal and lower cauline leaves cordate ..... 3. *A. cordifolia*
- Basal leaves ovate, cuneate to subcordate ..... 4. *A. cernua*

1. *Arnica parviflora* Gray. Small-flowered arnica.—Dry open woods on south and east slopes, also on north slope near summit; common. This is the first record as far north as Coos County. Canadian.

2. *Arnica spathulata* Greene. Spatulate arnica.—Dry thickets, east slope near the summit; occasional. Canadian. Differs from *A. parviflora* in having smaller, thicker leaves, more pronounced serrations, and the petioles being broadly winged. Our station for this narrow endemic, in Coos County, appears to be the most northern record obtained to date.

3. *Arnica cordifolia* Hook. Heart-leaved arnica.—East slope on dry open hillside; scarce. Transition.

4. *Arnica cernua* Howell. Nodding arnica.—Dry open woods on southwest slope; rare. This is a very interesting species of narrow distribution, known only from the mounttains of Josephine and Curry counties. Canadian.

19. SENECIO (Tourn.) L.

Annual
- Involucre bracts black-tipped ..... 1. *S. vulgaris*
- Involucre bracts not black-tipped ..... 2. *S. sylvaticus*

Perennial
- Leaves orbicular to ovate, dentate or somewhat incised or lobed, herbage glabrous ..... 3. *S. bolanderi*
- Leaves distinctly longer than broad, entire or few toothed above, herbage with a dense white tomentum or upper surface sometimes nearly glabrous
  - Petioles equal to or much shorter than the blades ..... 4. *S. canus*
  - Petioles longer than the blades ..... 5. *S. macounii*

1. *Senecio vulgaris* L. Common groundsel.—East slope growing in yard of Smith Claim; common. Introduced from Europe.

2. *Senecio sylvaticus* L. Wood groundsel.—East slope along Middle Elk Road on Coquille-Rogue River Divide. Dry ground, open wooded hillsides and thickets. Introduced from Europe.

3. *Senecio bolanderi* Gray. Bolander's senecio.—East slope in moist roadside meadow. A species of the California element in our flora. Canadian.

4. *Senecio canus* Hook. Gray senecio.—Dry open ground on south and southwest slopes; very common. A variable species which presents several perplexing forms. Probably entering our limits from California. Canadian.

5. *Senecio macounii* Greene. Clustered senecio.—Dry open ground, south slope; occasional. Canadian.

20. CIRSIUM (Tourn.) Hill.

Involucre bracts all prickle-tipped ..... 1. *C. vulgare*
Involucre bracts not all prickle-tipped, some scarious-tipped
Bracts prickle-margined ..... 2. *C. acanthodontum*
Bracts not prickle-margined ..... 3. *C. edule*

1. *Cirsium vulgare* (Savi) Airy-Shaw. Common bull thistle.—East slope, dry ground along Rock Creek; not common. Introduced from Europe.—*C. lanceolatum* (L.) Hill.

2. *Cirsium acanthodontum* Blake. Nelson's thistle.—Southeast slope along trail to Hells Half Acre; common. This is a narrow endemic known previously only from the lower Rogue River Canyon to the coast. It is very common in the Rogue River Mountains and the writer has collected it on Snow Camp Mountain in central Curry County. Transition to Canadian.

3. *Cirsium edule* Nutt. Edible thistle.—East slope along roadside, on moist ground in open woodland; common. Transition to Canadian.

REFERENCES

BAKER, W. H. 1950—Plant Records from Curry County, Oregon. Leafl. West. Bot. 6(4):82-84.

———1951—Ferns of Iron Mountain, Rogue River Range, Oregon 41(1):20-23.

CRONQUIST, ARTHUR 1947—Revision of the North American Species of Erigeron, North of Mexico. Brittonia 6(2):121-300.

JEPSON, W. L. 1923-25—A Manual of the Flowering Plants of California. Associated Students Store, Berkeley.

PECK, M. E. 1941—A Manual of the Higher Plants of Oregon.

SMITH, WARREN D. 1940—The Klamath Mountains Province, in Physical and Economic Geography of Oregon. Oregon State Board of Higher Education.

A Distributional Study of the Epiphytic Plants of the Olympic Peninsula, Washington

Babette Brown Coleman
University of Rochester, Rochester, New York

Walter C. Muenscher
Cornell University, Ithaca, New York

Donald R. Charles*
University of Rochester, Rochester, New York

In the generally mesophytic conditions of New York state were found on 63 hosts, chiefly native trees and shrubs, a total of 111 epiphyte species: 37 lichens, 3 algae, 25 liverworts, 43 mosses and 3 ferns (Brown, 1948).

For comparative data from a region of higher rainfall investigation of epiphytes was continued, during the summer of 1950, on the Olympic Peninsula in western Washington, where, in some places, the rainfall may reach 144 inches annually.

Epiphytes were collected at 20 sites within 15 general areas of the peninsula, differing in proximity to coast, in relationship to mountains and to prevailing winds, in altitude, in general habitat and in potential hosts.

On 43 species of conifers, hardwoods and shrubs were found altogether 195 epiphyte species, varieties and forms: 105 lichens, 36 liverworts, 48 mosses, 1 lycopsid and 5 ferns.

The total body of information obtained includes the identity of host species present and examined, identity of epiphytes found on each host and location of epiphyte on host at each of the collecting stations.

Out of this complex mass of data there should be extractible some general information about the factors that control epiphyte distribution, at least within the Olympic Peninsula. *A priori,* three main types of variable would seem likely to be relevant: 1) *biotic*—the potential hosts and competitors present at a given site; 2) *climatic*—perhaps chiefly the annual cycle, and range of variation within shorter intervals, of moisture and temperature at the epiphyte's surface; 3) *historic.*—relating to the opportunity each potential epiphyte has had to arrive, and become established, at a given site.

Considering the number of possible factors and their likely interrelationships it is scarcely to be expected that analysis of the data would be a simple matter. Certain initial steps, with, of course, most of the primary data will be reported here. Further study is in progress.

Brief Biogeography of the Olympic Peninsula

The Olympic Peninsula, 48 degrees N, is roughly an area of about 6000 square miles. North and south its extent is about 90 miles and that from east to west, approximately 60 miles. It shows a mountainous interior with Mt. Olympus, the highest peak, rising some 7900 feet above sea level and many additional peaks of comparable height. The lowland exterior contains many

*Deceased

rivers originating from the mountain glaciers of the high country. Lowland lakes are few, scattered and of variable size. An equable climate prevails in the lowlands because of the proximity of the Japanese current. Rainfall is high on the western side of the peninsula but drops off as the rain shadow of the mountains is reached, especially in the northeast from Crescent Lake to Sequim and Port Discovery.

Ecologically the peninsula falls into two principal regions classified on the basis of the vegetation: the boreal and the austral. Jones (1936) further subdivides the former into three biogeographical divisions each with its characteristic phytosociological units: a) the arctic-alpine zone from 5000 to 7000 feet in elevation, and treeless; b) the Hudsonian zone from 3500 to 5000 feet in elevation, characterized by the *Chamaecyparis nootkatensis-Abies lasiocarpa-Tsuga mertensiana* climax; c) the Canadian zone from 1500 to 3000 feet in elevation, characterized by the *Tsuga heterophylla-Abies amabilis-Pinus monticola* climax. The austral region is represented by one biogeographical division, the transition zone, often referred to as the Pacific or humid transition area, of which two types of phytosociological units are characteristic. From sea level to 1500 or 2000 feet the *Tsuga heterophylla-Thuja plicata* climax dominates with a *Pseudotsuga taxifolia* subclimax. From the dunes at sea level to about 1000 feet there is often found a *Picea sitchensis-Tsuga heterophylla* climax. Piper (1906) states that the heavy precipitation results in modifying greatly the effect of altitude in the Olympic mountains so that the lines of zonal demarcation are much obscured and many humid transition species ascend to the Hudsonian zone and the great majority of the plants are the same as those in the Cascades.

PROCEDURE

Hosts selected for study were the dominant trees of the associations found at the several stations, the understory trees and a number of conspicuous shrubs. Generally several individuals of each host present at a collecting site were examined, usually at specified regions: trunk base, lower trunk to first branch, upper trunk among branches, lower branches, upper branches and branchlets. The variation in size of the hosts, the inaccessibility of their upper parts when standing and the limitation of time greatly curtailed the completeness and uniformity of these collections. Fallen trees in the forest and logging operations, temporarily halted in certain regions, did facilitate the collecting at several stations.

Collections were pressed, dried and shipped to Cornell University and ultimately to the University of Rochester for laboratory study and determination.

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Fig. 1.—Map showing 15 areas where collections were made.

THE COLLECTING STATIONS

Both biotic and climatic factors differed among the stations. As much as could be obtained of the relevant geographical and climatological data is summarized in fig. 1 and, with some ecological notations, in table 1.

TABLE 1.—Physical characteristics of the 20 stations.*

Habitat type and station	Biogeographical zone	Location	Altitude range—feet	Average rel. humidity %	Average temp. degrees F.	Average annual ppt.—in.	Prevailing wind	Growing season—days
Rain forest								
Aa	Humid transition	Alava & Sand Pt. trails	100	80+	49	115	sw	166
B	"	Ozette L.	100	80+	49	115	sw	166
J	"	Mouth-Hoh R.	0-50	80+	49	79-125	sw	218
K	"	Middle Hoh R.	500	80+	49	115	sw	166
L	"	17+ mi. up Hoh. R.	1000	52-80	49	109	sw	166
O	"	Quinault L. & R.	300	52-80	50	122	w	200
Fa	"	Wolf Cr.-Elwha R. valley	1000+	52-80	47			
Special rain forest								
N	"	Raft R.	300	80—	50	122	w	200
Fog forest								
C	"	Cape Flattery	0-86	86-91	49	84	e	306
D	"	Neah Bay	0-86	80+	49	109		
Ha	"	Sequim Bay Park	0-100	80+	48	15	w	170
Ia	"	Port Discovery Bay	0	80+	50	20	nw	256
Coast forest								
Ab	"	Cape Alava & Sand Pt.	0-100	80+	49	79-125	w	218
M	"	Queets, Kalaloch & La Push	0-100	80+	49	79-125	w	206-218
Relatively dry forest								
E	"	Crescent L.	700	76-79	47	41	s	203
Fb	Canadian	Upper Elwha valley	2000-3000	52-80				
Dry forest								
Hb	Humid transition	Dungeness R. valley	100-187	80+	48	15	w	170
Ib	"	Inland-Port Disc. Bay	80	80—	50	20	nw	256
High forest								
Fc	Hudsonian	Mile 10-Hurricane R.	4000	52-80				
G	"	Hurricane Ridge	4000-5000	52-80				

* Based on data recorded for Western Washington in the Climatic Summary of the United States prepared by the Weather Bureau of the Dept. of Agriculture.

TABLE 2.—Distribution of the hosts at the stations

	A		B	C	D	E	F			G	H		I		J	K	L	M	N	O	*	**
	a	b					a	b	c		a	b	a	b								
1 Taxus brevifolia	....		....	....			+					....					....		....	....	40	35
2 Abies grandis						....	....				....	....				....					25	25
3 Abies lasiocarpa										....											5	5
4 Picea sitchensis	....	....	....	....	....						+		....		....	....	....	....		....	60	55
5 Pinus contorta																			....		5	5
6 Pinus monticola									+	....				....					....		20	15
7 Pseudotsuga taxifolia						....	....	....	....		....	....		....		....	....		....	....	55	55
8 Tsuga heterophylla	....	....	....	....			....		....	....				....	....	....	....	....	....	....	70	70
9 Tsuga mertensiana										—											5	5
10 Chamaecyparis nootkatensis										....											5	5
11 Thuja plicata	....		....	....		+			....		....	....		....		....	....	+		....	60	50
12 Populus tremuloides						....															5	5
13 Populus trichocarpa						....						—			....	....	....			....	30	30
14 Salix lasiandra													....		....						10	10
15 Salix scouleriana		....	....								....				....						20	20
16 Salix sitchensis						....	....					....		....	....	+		+		....	40	30
17 Juglans nigra†													....								5	5
18 Corylus californica												....									5	5
19 Alnus oregona	....	....	....	....	....		....				....	....		+	....	....	....	....		....	70	65
20 Fagus sylvatica†			....																		5	5
21 Quercus garryana												....									5	5
22 Ribes sanguineum												....									5	5
23 Amelanchier florida						....	....					....									15	15
24 Crataegus douglasii						....						....		+							15	10
25 Holodiscus discolor						....	....				....	....		....							25	25

TABLE 2.—(Continued)

	A		B	C	D	E		F			G	H		I		J	K	L	M	N	O	*	**
	a	b					a	b	c			a	b	a	b								
26 Osmaronia cerasiformis																....	....					10	10
27 Prunus domestica†																			....			5	5
28 Prunus emarginata						....	....						....		....							20	20
29 Pyrus diversifolia	....	....	....	....		+	....							....		....		....	....		....	55	50
30 Rubus spectabilis		+																	....			10	5
31 Acer circinatum																....	....	....			....	20	20
32 Acer glabrum						....	....	+														15	10
33 Acer macrophyllum						....	....					....			+	....	....	....			....	40	35
34 Acer platanoides†			....																			5	5
35 Aesculus hippocastanum†			....																			5	5
36 Rhamnus purshiana	....	....	+	....		....							—			....	....	....		....	....	50	45
37 Cornus nuttallii															+							10	5
38 Arbutus menziesii						....		+					....		....							20	15
39 Arctostaphylos tomentosa								+							....							10	5
40 Rhododendron macrophyllum															....							5	5
41 Lonicera involucrata																			....			5	5
42 Sambucus callicarpa		....									—					....	....					20	20
43 Sambucus glauca													....									5	5
Number of hosts seen	7	8	11	7	2	15	12	4	4	5	9	17	4	14	13	13	11	9	6	12			
Number of hosts collected	7	7	10	7	2	13	11	1	4	5	8	17	4	10	13	12	11	7	6	12			

* % of stations where host seen
** % of stations where host collected
† introduced species
\+ host seen but not collected
.... host seen and collected
— host seen and no epiphytes observed on it

THE HOSTS

The 43 hosts were 11 gymnosperms, from 8 genera and 2 families, and 32 angiosperms, from 24 genera and 12 families. They are listed, with station and epiphyte annotations, in APPENDIX A.

Only a minority of the hosts were commonly or usually encountered, as judged either by stations or by habitat types:

% at which present Frequency category	5-19 rare	20-39 infrequent	40-59 common	60-100 abundant
		% of hosts		
By stations	56	21	14	9
By habitats	47	21	5	26

The most frequent species, by stations, were as follows: abundant.—Picea sitchensis, *Tsuga heterophylla, Thuja plicata, Alnus oregona;* common.—*Taxus brevifolia, Pseudotsuga taxifolia, Salix sitchensis,* Osmaronia cerasifor-

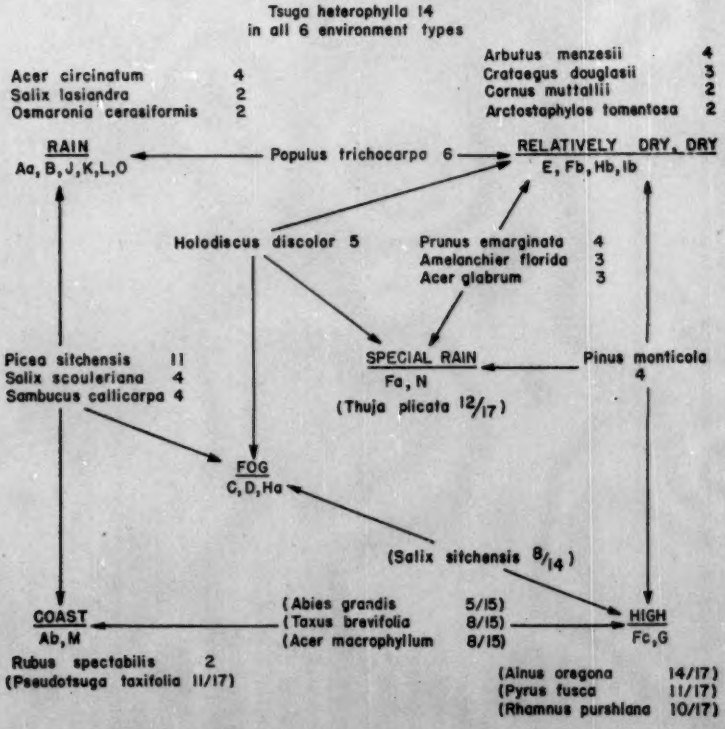


Fig. 2.—Summarized distribution of 27 hosts among 19 stations of 6 environmental types. Species in parentheses are *absent* from the one or two types of environment indicated, but present at one station or more in each of the other types, in the total proportion shown. Station Ia, in a salt marsh, 16 hosts found at only one station each have been omitted.

mis, *Pyrus diversifolia, Acer macrophyllum*. The 8 italicized hosts, plus Abies grandis and Rhamnus purshiana, were found to be the most versatile with respect to habitat, appearing at 1 station or more in at least 4 of the 6 habitat types. The detailed distribution of hosts among stations is shown in table 2. When summarized by habitats, most compactly as in fig. 2, the data form a two-dimensional array with rain and high forest, coast and dry forest, as pairs of extreme opposites. This situation might well be taken as a trivial result of formal analysis, *except* that the distribution of lichen, liverwort and moss epiphytes all fall into a similar pattern and cannot be as compactly shown, so far as we have been able to ascertain, in any other way.

THE EPIPHYTES

The 195 epiphytes were distributed taxonomically as follows:

	Lichens	Hepaticae	Musci	Pteridophyta
Families	21	12	11	2
Genera	39	17	25	5
Species	95	36	48	6

They are listed with station, host and location-on-host annotations in APPENDIX B, and their distribution with respect to habitats is summarized in figs. 3-6.

Like the hosts, the epiphytes were mostly infrequent or rare, as appears in table 3. The abundant and common species are listed in table 4.

THE DISTRIBUTION OF EPIPHYTES AMONG STATIONS

Figs. 3-6 convey only a small portion of the total information on epiphyte distribution among the 20 stations. Another part comes into focus when we consider a question prompted by the possibility that the controls might really be rather simple: Can the stations be arranged in such spatial relations, preferably within a plane, that the number of epiphyte species per station varies in a simple and orderly fashion, for each class separately?

One such arrangement, adumbrated in figs. 3-6, is shown in fig. 7 where it may first be noted that stations classified as similar habitats on the basis of field observation lie contiguously.

When so arranged lichen, liverwort and moss frequencies each decrease outward, and fairly symmetrically, from a central peak (figs. 8-10) and angiosperm host frequency varies in a similar but less regular way (fig. 11). Pteridophyte and gymnosperm (host) species, although too few to give significant evidence, also fall into fairly well-ordered patterns, centered in rain and special rain forest.

TABLE 3.—Station distribution of epiphytes.

% of stations at which present	Rating	Lichens	Hepaticae	Musci	Pteridophyta
			% of species		
60-100	abundant	9.5	2.8	12.5	0
40- 59	common	10.5	11.1	12.5	17
20- 39	infrequent	31.4	36.1	29.2	50
5- 19	rare	48.6	50.0	45.8	33

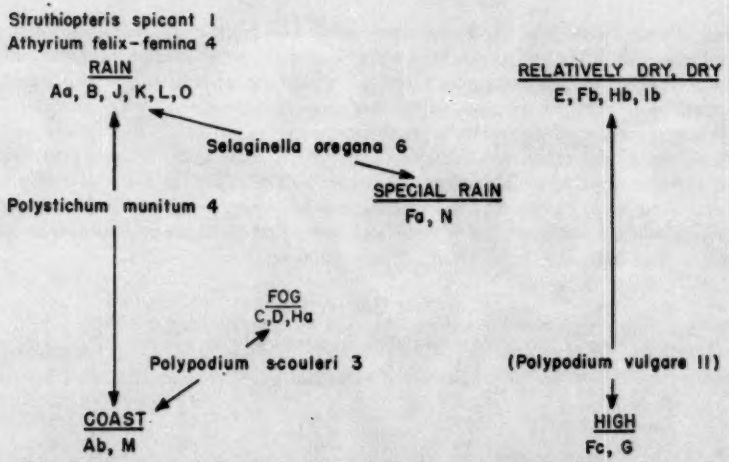


Fig. 3.—Summarized distribution of 6 pteridophytes among 19 stations of 6 environmental types. Species in parentheses are *absent* from the one or two types of the environment indicated, but present at one station or more in each of the other types, to the total shown.

That other, and quite different, arrangements of the data are possible cannot be denied here, but four sorts of evidence indicate that the present arrangement is meaningful. (1) A number of independent attempts have led to essentially the same pattern. (2) The distribution of *individual species* turns

TABLE 4.—The abundant and common epiphytes of the Olympic Peninsula.

	ABUNDANT	
Lichens		*Musci*
Graphis scripta	Parmelia enteromorpha	Dicranum fuscescens
Cladonia sp.	Parmelia saxatilis	Eurynchium oreganum
Pertusaria multipuncta	Parmelia sulcata	Eurynchium stokesii
Ochrolechia tartarea	Cetraria glauca	Isothecium stoloniferum
Usnea hirta	Cetraria tuckermani	Neckera douglasii
		Antitrichia curtipendula
Hepaticae		
Frullania nisquallensis		
	COMMON	
Lichens		*Musci*
Sphaerophorus globosus	Alectoria sarmentosa	Orthotrichum lyellii
Parmelia physodes	Usnea ceratina	Ulota phyllantha
Cetraria lacunosa	Usnea dasypoga	Mnium punctatum
Cetraria scutata	Usnea plicata	Hylocomium loreum
Nephromopsis ciliaris	Ramalina farinacea	Hypnum circinale
Lepraria sp.		Plagiothecium undulatum
Hepaticae		*Pteridophyta*
Scapania bolanderi	Radula bolanderi	Polypodium vulgare
Porella navicularis	Frullania franciscana	

out, in many cases, to be some particular strip or approximate ellipse within fig. 7. A few examples are: Selaginella oregana—BJKLMNO; Metzgeria fruticulosa—AbJL; Orthotrichum lyellii—AaBEFaHbJKLO; Lecanora hageni —EIaJ; Lepidozia reptans—AaLNO; Buellia disciformis—BEHbL; Xanthoria candelaria—HaHbIa; Parmelia perlata—AbCD. (Study of the data in this aspect is not yet complete.) (3) Individual families or family groups, at least of lichens, are distributed mainly over limited and continuous, but rather widely varied, portions of the diagram, as can be seen by comparing table 5 with fig. 7. (4) The inter-family differences of position within fig. 7 fall into quite good order relative to the taxonomic seriation (table 6).

The two-dimensionality of figs. 7-11 suggests that the differences, in suitability for epiphyte existence, among the areas of the Olympic Peninsula we have examined might be chiefly in *two* variables.

Pointing towards the same conclusion are the contrasts in shape and orien-

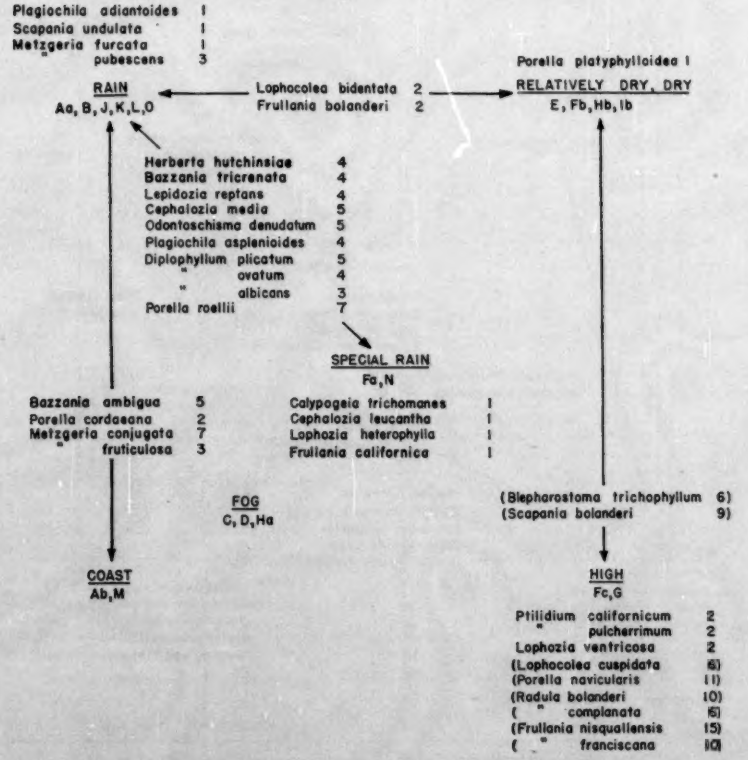


Fig. 4.—Summarized distribution of 36 liverworts among 19 stations of 6 environmental types. Species in parentheses are *absent* from the one or two types of environment indicated, but present at one station or more in each of the other types, to the total shown.

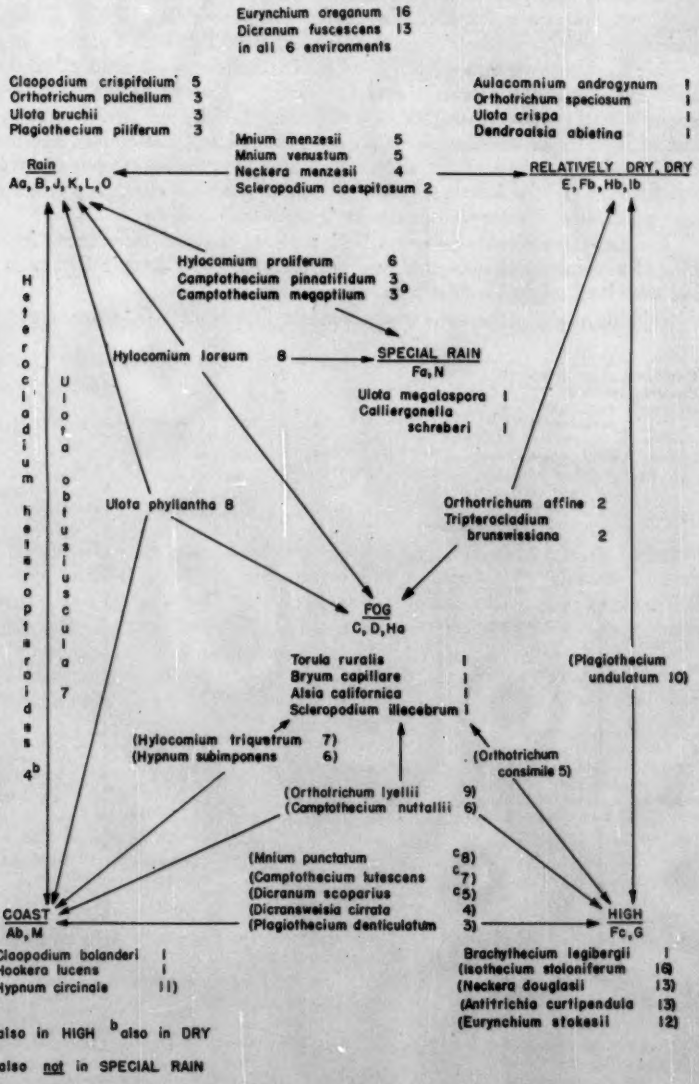


Fig. 5.—Summarized distribution of 48 mosses among 19 stations of 6 environmental types. Symbols as in figs. 3 and 4.

TABLE 5.—Distribution of lichen families among stations.

	Aa	Ab	B	C	D	E	Fa	Fb	Fc	G	Ha	Hb	Ia	Ib	J	K	L	M	N	O
	Number of species present																			
Sphaerophoraceae Pyrenulaceae Arthoniaceae Graphidaceae	1	2	3	2	1	1	2	0	0	0	2	2	3	0	2	2	3	1	1	3
Thelotremaceae Ephebaceae Collemaceae Pannariaceae	0	0	2	0	0	3	0	0	0	2	1	0	0	0	1	1	3	1	0	0
Stictaceae Pelitgeraceae	2	2	7	0	3	3	0	0	0	0	0	0	0	0	5	2	9	3	0	2
Lecideaceae Cladoniaceae	0	2	2	1	0	2	2	0	2	2	2	4	2	1	2	3	4	2	3	1
Pertusariaceae Lecanoraceae	1	3	6	3	1	7	4	0	0	5	5	7	4	4	7	3	4	2	1	3
Parmeliaceae	6	6	13	10	10	12	9	0	5	10	11	12	9	9	10	5	9	8	4	8
Usneaceae	5	9	7	6	9	5	4	1	4	4	8	10	2	8	3	0	0	4	0	5
Caloplacaceae Teloschistaceae Buelliaceae	0	2	2	3	0	5	0	0	0	1	4	7	4	0	0	0	1	0	0	1
Physciaceae Leprariaceae	0	3	1	2	0	1	1	0	1	1	6	4	3	3	1	0	0	1	0	0

TABLE 6.—Distribution of lichen families among habitats.

	Family groups		Habitat						
			A	B	Coast	Fog	Dry	Rain	High
					Favorable stations				
1	Pyrenulaceae Sphaerophoraceae	Arthoniaceae Graphidaceae	8	49	—	—	—	—	—
2	Thelotremaceae Ephebaceae	Collemaceae Pannariaceae	9	13	—	—	—	—	—
3	Stictaceae	Peltigeraceae	12	68	—	—	—	BL	—
4	Lecideaceae	Cladoniaceae	13	56	—	—	—	—	—
5	Pertusariaceae	Lecanoraceae	11	70	—	—	EHb	BJ	—
6	Parmeliaceae		20	350	—	CDHa	EHb	BJ	G
7	Usneaceae		16	180	Ab	DHa	HbIb	—	—
8	Caloplacaceae Teloschistaceae	Buelliaceae	10	45	—	—	Hb	—	—
9	Physciaceae	Leprariaceae	6	52	—	Ha	Hb	—	—

A—Total species found.
B—Total number of collection records
Favorable station—Station with half or more than half of the number shown in column A for the given family group

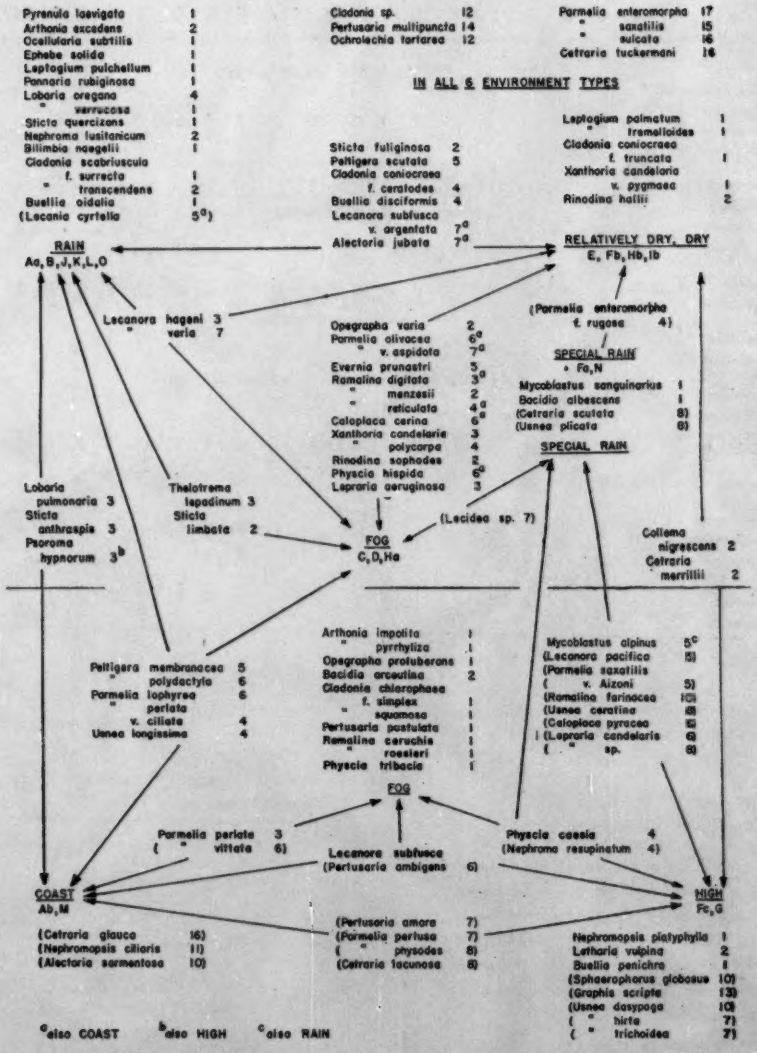


Fig. 6.—Summarized distribution of 105 lichens among 19 stations of 6 environmental types. Symbols as in figs. 3 and 4.

tation among the lichen, liverwort and moss frequency contours: as though lichens could tolerate a broader range of one variable, x, than of another, y; mosses, about equal ranges; and liverworts, wider differences of y than x. (Gymnosperm hosts and fern epiphytes seem, in this respect, to resemble the

liverworts.) A similar situation may be noted among the families of lichens. Angiosperm hosts, with their major axis oblique to both the lichens' and liverworts', might be limited by some *relation* between x and y, more than by the absolute values.

Insofar as epiphyte distribution is controlled largely by two factors, appearing as approximately rectangular coordinates lying obliquely in figs. 7-11, neither factor is likely to be biotic. The biotic factors, both hosts and competitors, are distributed in the same figures on roughly polar coordinates, i.e., as concentric circles or ellipses rather than parallel transects. Altogether, x and y would seem more probably to be climatic.

However, considering the possible complexity of interrelationships among the variables, it seems essential to proceed to a direct inquiry into the role of biotic factors.

THE DISTRIBUTION OF EPIPHYTES AMONG HOSTS

The total epiphytes of each class found on each host are shown, by number of species and of collection records, for the first 10 feet of the trunk and for the whole host, in table 7. By any of these criteria the hosts vary widely in wealth of epiphyte garniture: from Alnus oregona with 55 lichens, 10 liverworts, 25 mosses and 4 ferns to Rubus spectabilis with 1 moss and Tsuga mertensiana with no epiphytes.

Table 7 may, however, give a very inaccurate picture of the hosts' suitability as substrates for epiphyte growth, because of the differential station distribution of hosts. Suppose that climatic factors were decisive: any host found mostly or only at stations unfavorable climatically for epiphytes would

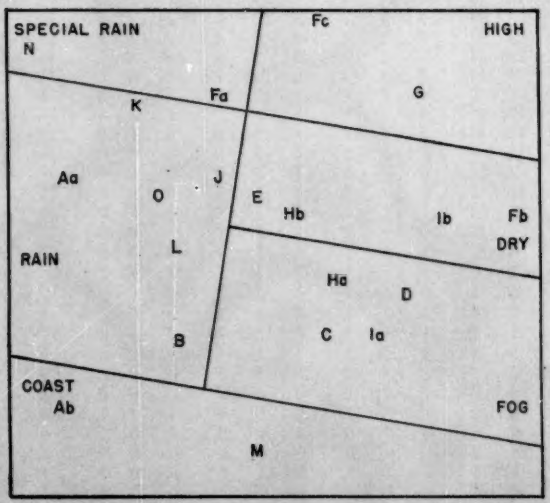


Fig. 7.—Arrangement of the 20 substations on which the number of lichen, liverwort and moss epiphyte and angiosperm host species found varies, separately for each class, in an orderly and simple fashion.

bear few species and appear seldom in collection records; and similarly hosts in climatically favorable stations would seem to be especially receptive to epiphytes.

For this possibility no infallible correction is apparent. One method that seems to be reasonable is to take the ratio of (i) total epiphyte species of a

TABLE 7.—Number of epiphyte collections and species on hosts. A—Collection records on entire host; B—Collection records on 1-10 feet of trunk of host; C—Number of species; D—Number of species on entire host; E—Number of species on 1-10 feet of trunk of host.

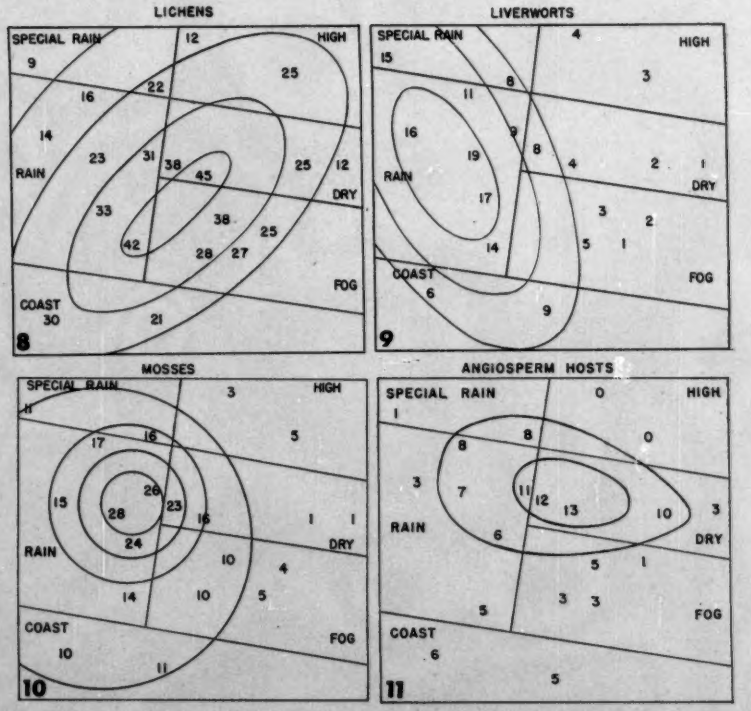
	Lichens			Hepaticae			Musci			Pteridophyta			Totals			
Hosts	A	B	C	A	B	C	A	B	C	A	B	C	A	B	D	E
19	147	78	55	33	33	10	81	76	25	17	17	4	278	204	94	81
4	95	51	46	26	21	12	39	27	15	12	9	5	172	108	78	61
8	95	45	36	29	24	15	31	28	12	11	9	6	166	106	69	56
7	90	68	36	16	16	9	41	38	15	4	2	3	151	124	63	55
29	33	26	28	28	27	14	46	46	19	8	8	2	115	107	63	60
13	40	16	29	16	14	8	45	42	21	8	8	2	109	80	60	43
33	21	20	21	15	15	7	49	44	23	10	10	3	95	89	54	53
11	39	20	29	17	17	8	28	25	12	4	3	3	88	65	52	38
16	49	46	29	9	9	4	15	15	10	1	1	1	74	71	44	44
1	12	4	12	38	35	13	20	20	10	4	4	2	74	63	37	28
25	38	38	20	11	11	8	4	4	3	0	0	0	53	53	31	31
31	4	3	4	14	14	9	30	29	18	5	5	2	53	51	33	31
36	1	1	1	17	17	8	28	28	14	2	1	2	48	47	25	24
23	29	20	27	2	2	2	11	11	10	0	0	0	42	33	39	30
6	21	16	19	11	11	11	9	9	8	0	0	0	41	36	38	33
15	23	23	21	5	5	3	10	10	8	2	2	1	40	40	33	33
28	23	23	17	4	4	4	6	6	5	0	0	0	33	33	26	26
18	23	23	23	2	2	2	6	5	6	0	0	0	31	30	31	30
2	13	4	11	8	8	7	10	10	7	0	0	0	31	22	25	16
12	6	6	6	4	4	4	15	15	15	0	0	0	25	25	25	25
14	15	15	15	3	3	3	5	5	5	1	1	1	24	24	24	24
20†	13	13	13	4	4	4	6	6	6	0	0	0	23	23	23	23
32	12	12	9	3	3	3	6	6	6	0	0	0	21	21	18	18
10	17	12	17	0	0	0	2	2	2	0	0	0	19	14	19	14
21	13	12	13	0	0	0	5	5	5	0	0	0	18	17	18	17
40	16	16	16	1	1	1	1	1	1	0	0	0	18	18	18	18
17†	15	14	15	0	0	0	2	2	2	0	0	0	17	16	17	16
3	11	8	11	3	3	3	3	3	3	0	0	0	17	14	17	14
42	0	0	0	5	5	5	7	7	7	4	4	2	16	16	14	14
37	6	6	6	6	6	6	3	2	3	0	0	0	15	14	15	14
38	4	3	4	2	2	2	8	8	5	0	0	0	14	13	11	10
5	1	1	1	3	3	3	7	7	7	0	0	0	11	11	11	11
35†	5	5	5	3	3	3	1	1	1	0	0	0	9	9	9	9
24	2	2	2	2	2	2	5	5	5	0	0	0	9	9	9	9
27†	8	8	8	0	0	0	0	0	0	0	0	0	8	8	8	8
26	0	0	0	2	2	2	5	5	4	1	1	1	8	8	7	7
22	6	6	6	0	0	0	0	0	0	0	0	0	6	6	6	6
43	6	6	6	0	0	0	0	0	0	0	0	0	6	6	6	6
41	1	1	1	1	1	1	3	3	3	0	0	0	5	5	5	5
39	4	4	4	0	0	0	0	0	0	0	0	0	4	4	4	4
34†	0	0	0	1	1	1	2	2	2	0	0	0	3	3	3	3
30	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

given class found on a given host over all stations at which the host appears to (ii) average *total* species of the same class found at the same stations. This gives a *relative receptivity*, fairly independent of the climates at the stations where the host appears. The appropriate data are contained in table 7 and APPENDIX B; the ratios calculated from them are shown in table 8.

The hosts happen to fall, by relative receptivity, into very nearly the same order as in table 7, with more than a hundredfold difference between Acer platanoides and Alnus oregona. The number of hosts in successive receptivity ranges are:

Range	0-.10	.11-.20	.21-.40	.41-.80	.81-1.60	1.60-
Species	5	6	8	15	8	1

The 11 gymnosperms appear on the whole to be more receptive than the 32 angiosperms, with 5 species among the 10 most receptive hosts and only 1 among the 10 least receptive.



Figs. 8-11. Total species found at each of the 20 substations shown in fig. 7.—8. Epiphytic lichens; 9. Epiphytic liverworts; 10. Epiphytic mosses; 11. Angiosperm host species.

TABLE 8.—Relative receptivity of 43 hosts to epiphytes of 3 classes.

Host	Receptivity				Total stations
	Lichens	Liverworts	Mosses	Total	
Alnus oregona	1.94	1.05	1.56	1.68	13
Picea sitchensis	1.75	1.21	1.00	1.43	11
Tsuga heterophylla	1.53	1.53	.87	1.36	14
Pseudotsuga taxifolia	1.45	1.08	1.09	1.28	11
Pinus monticola	.97	1.65	1.41	1.19	3
Pyrus diversifolia	.98	1.35	1.19	1.11	10
Thuja plicata	1.05	.84	.85	.96	10
Populus trichocarpa	1.07	.71	.94	.95	6
Acer macrophyllum	.73	.65	1.12	.85	7
Salix sitchensis	.95	.48	.55	.75	6
Rhododendron macrophyllum	.64	.50	1.00	.64	1
Amelanchier florida	.77	.30	.55	.64	3
Taxus brevifolia	.43	1.01	.60	.61	7
Holodiscus discolor	.60	1.60	.23	.60	5
Chamaecyparis nootkatensis	.68	0	.40	.58	1
Salix scouleriana	.60	.38	.53	.55	4
Juglans nigra	.56	0	.40	.52	1
Abies lasiocarpa	.44	1.00	.60	.52	1
Prunus emarginata	.52	.73	.36	.50	4
Acer circinatum	.16	.64	.76	.49	4
Corylus californica	.51	.50	.38	.48	1
Abies grandis	.37	1.03	.43	.48	5
Salix lasiandra	.52	.60	.32	.46	2
Rhamnus purshiana	.05	.70	.80	.42	9
Populus tremuloides	.16	.50	.65	.36	1
Fagus sylvatica	.31	.29	.43	.33	1
Acer glabrum	.30	.38	.31	.31	2
Pinus contorta	.11	.20	.64	.31	1
Quercus garryana	.29	0	.31	.28	1
Sambucus callicarpa	0	.69	.44	.23	4
Cornus nuttallii	.16	.75	.13	.22	1
Arbutus menziesii	.11	.43	.37	.20	3
Prunus domestica	.38	0	0	.20	1
Arctostaphylos tomentosa	.16	0	0	.14	1
Crataegus douglasii	.05	.33	.30	.14	2
Aesculus hippocastanum	.12	.21	.07	.13	1
Lonicera involucrata	.05	.11	.27	.12	1
Osmaronia cerasiformis	0	.20	.19	.11	2
Ribes sanguineum	.13	0	0	.09	1
Sambucus glauca	.13	0	0	.09	1
Rubus spectabilis	0	0	.09	.02	1
Acer platanoides	0	.07	.01	.015	1
Tsuga mertensiana	0	0	0	0	1

In table 8 only 12 of the hosts seem to be more receptive to one class of epiphytes than to another; or at least these are the only 12 for which there is a statistically significant difference:

Higher in lichens
Prunus domestica
Higher in liverworts
Taxus brevifolia
Holodiscus discolor
Cornus nuttallii
Higher in mosses
Pinus contorta
Lower in lichens
Acer circinatum
Rhamnus purshiana
Populus tremuloides
Sambucus callicarpa
Arbutus menziesii
Crataegus douglasii
Osmaronia cerasiformis

TABLE 9.—Certain characteristics of the 10 most, and the 9 least, receptive epiphyte hosts (Sargent, 1921; Bailey and Bailey, 1949; observation).

Rank	Species	Potential trunk diameter—ft.	Height —ft.	Bark characteristics
1	Alnus oregona	3	40-50 understory	¾ in. thick, close, roughened by small wart-like excrescences, with thin outer layer, pale gray or white
2	Picea sitchensis	3-4, 15-16	100-200	¼-½ in. thick, broken on surface into large, thin, loosely attached scales
3	Tsuga heterophylla	6-10	200	on young trees thin, broken into scales, shallowly fissured; on older trees 1-1½ in. thick, divided into flat ridges with close, brown scales
4	Pseudotsuga taxifolia	3-4, 10-12	200	on young trees smooth and thin, on old trunks 10-12 in. thick, broken into rounded ridges with closely appressed scales
5	Pinus monticola	4-5, 7-8	100-150	on young trees smooth and thin, on old trees ¾-1½ in. thick, divided into nearly square plates by cross and longitudinal fissures
6	Pyrus diversifolia	12-18 in.	3-40 understory	¼ in. thick, covered by large, thin, loose, plate-like scales
7	Thuja plicata plicata	up to 15	200	½-¾ in. thick, irregularly divided by narrow fissures into broad ridges which are broken on surface into long, narrow, loose scales
8	Populus trichocarpa	1-3	30-100	½-2½ in. thick, deeply divided into broad, ridges broken into thick, close scales
9	Acer macrophyllum	2-3	80-100	½-¾ in. thick, deeply furrowed and broken on surface into small, square, plate-like scales
10	Salix sitchensis	up to 1	25-30 understory	⅛ in. thick and broken into irregular, close scales
34	Arctostaphylos tomentosa	small	2-10 shrub	
35	Crataegus douglasii	small	5-24 shrub or tree	
36	Aesculus hippocastanum	medium	introduced tree	thin, broken into plates
37	Lonicera involucrata	small	1-6 shrub	
38	Osmaronia cerasiformis	small	3-12 shrub	smooth
39	Ribes sanguineum	small	3-9 shrub	shreddy
40	Sambucus glauca	small	6-10 shrub or tree to 25	
41	Rubus spectabilis	small	3-9 shrub	shreddy on old stems, crimson on young shoots
42	Acer platanoides	medium	introduced tree	shallow fissured into narrow ridges

What properties of the hosts might determine their wide differences in total receptivity is not readily apparent. Some of the obvious possibilities are compiled, for the 10 most and the 10 least receptive hosts, in table 9. The only correlate of receptivity which we can find there is that the least receptive hosts are chiefly shrubs. They are relatively short, small in diameter and probably have a smooth bark. Hence they do not present the variation in host zones nor the variation in surface characters afforded by the most receptive hosts.

Whatever the host factors are, they seem to operate rather comparably on different families, or family groups, of lichens (table 10): the *relative* frequency of species from different families is fairly uniform, at least among those 19 hosts which each bore 15 or more species of lichens altogether. This is in sharp contrast to the differential distribution of lichen families among habitats, already noted in table 6.

HOST-STATION INTERACTIONS

Once again it should be recalled that different hosts and possible competitors occupy different combinations of stations, different stations contain different arrays of hosts and rivals. What appears to be biotic effects might well arise from the former fact; what seem to be climatic, from the latter. The only apparent method that might disentangle the two sorts of variable is to examine, for each host separately, the station-distribution of its potential epiphytes, those that are known to be able to live on it by their presence on it at one or more stations.

For this purpose only the lichens have sufficient species. We shall neglect possible competitors and restrict attention to the 4 hosts that each bear, altogether, more than 30 lichen species. The results are shown in tables 11-14.

A strong host-station interaction is evident. Picea sitchensis bears at station C about 80% of its potential epiphytes that are present there, with fair consistency among family groups, but none at Aa. Pseudotsuga taxifolia carries none of its potentials at stations N and O, but a high and consistent proportion at Ha. Tsuga heterophylla is bare of lichens at M and J, although 15 and 16 species are present, but at Aa supports nearly every lichen known to be able to exist on it and present there. Alnus oregona is a poor lichen host at Aa and C, but very receptive at D and J.

The approximate family-to-family uniformity in the station-to-station differences of lichen frequency, at least on the 4 hosts we have so far examined, agrees with what table 10 indicates: that the hosts vary more in general receptivity for lichens than in suitability for particular groups within the class. In that case it should be fair enough to examine the host-station interaction further in terms simply of the proportion of *total* lichen epiphytes, present at a given station, that actually occurs on each particular host there. This is done, for the 18 hosts found at 2 or more stations and having 10 or more potential epiphytes, in table 15. There, again, will be noted, but now freed of possible effects of the differential host distribution among stations: (1) *Host differences in receptivity,* e.g. Taxus brevifolia poor at 6 of 7 stations in contrast to Alnus oregona good at 7 of 12; (2) *Station differences* that can scarcely be ascribed to anything but *climatic factors;* e.g. few lichens on 5 of the 6 hosts present at Aa, although each is highly receptive at some other station, and

TABLE 10.—Distribution of 9 family groups of lichens among the 19 most receptive hosts (arranged in order of total lichen species present). A—Total species; B—Average species per host.

Family group (cf. table 5)	Host species (cf. table 2) 19	4	7	8	11	13	16	29	23	18	33	15	25	6	28	10	40	14	17	A	B
	Total species of family on given host																				
1	3	2	1	2	1	2	0	2	0	0	2	1	0	1	1	0	0	1	1	8	1.05
2	3	1	1	0	0	5	0	0	0	0	0	0	0	0	0	2	0	1	0	9	.68
3	2	6	1	1	0	8	0	0	0	0	0	1	0	0	0	0	0	0	2	0	12	1.11
4	3	4	3	4	2	3	1	2	2	1	2	1	0	4	0	2	0	1	1	13	1.89
5	10	3	5	3	6	4	4	5	7	3	1	2	5	2	1	4	1	3	2	11	3.73
6	17	15	12	15	9	7	9	11	10	8	3	9	8	9	9	5	8	2	4	20	8.94
7	9	10	10	9	7	0	9	6	3	5	5	6	5	2	4	2	6	1	3	16	5.37
8	4	3	0	0	2	0	4	0	5	4	2	1	1	0	0	1	0	2	3	10	1.68
9	3	3	3	2	2	0	2	2	0	2	6	0	1	1	2	1	1	2	1	6	1.78

relatively plentiful lichens on 6 of 8 hosts at Ha, although each bears few or none at some other station. (3) *Host-station interactions*, e.g., Alnus oregona relatively receptive at 10 out of 12 stations and Acer macrophyllum highly receptive at only 1 out of 7 stations.

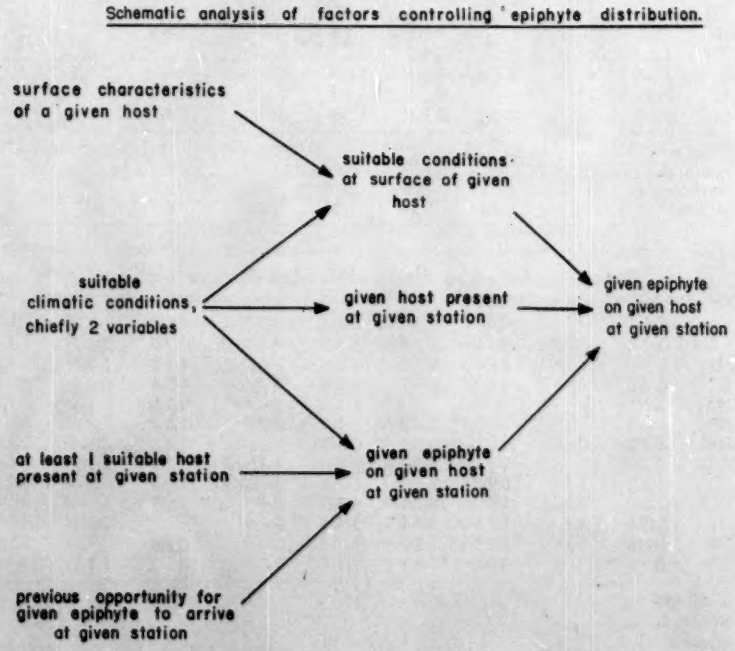

Schematic analysis of factors controlling epiphyte distribution.
surface characteristics of a given host
suitable conditions at surface of given host
suitable climatic conditions, chiefly 2 variables
given host present at given station
given epiphyte on given host at given station
at least 1 suitable host present at given station
given epiphyte on given host at given station
previous opportunity for given epiphyte to arrive at given station

Fig. 12.—Schematic analysis of factors controlling epiphyte distribution.

DISCUSSION

The factors controlling epiphyte distribution appear, from the present data, to be and to operate somewhat as suggested in fig. 12. Undoubtedly the scheme is oversimplified, particularly in omitting possible competitors. Furthermore, we have restricted ourselves to the single criterion, presence of the epiphyte; in respect to abundance the picture might be rather different.

Fig. 12 raises many more questions than it suggests possible answers. What are the two principal climatic variables, if figs. 3-6 have been correctly interpreted as indicating only two? What are the host-surface characteristics

TABLE 11.—Lichens of different family groups on *Pseudotsuga taxifolia* at 11 stations, relative to lichens present that are potential epiphytes of *P. taxifolia* and to total lichen epiphytes present.

Station	Family group, same sequence as in table 5								
	1	2	3	4	5	6	7	8	9
E	1-1-1			1-1-2	1-5-7	4-11-12	1-4-5	0-0-5	0-1-1
Fa	1-1-2			1-1-2	3-4-4	6-10-10	2-4-4		0-1-1
Fb							1-1-1		
Fc				2-2-2	0-2-2	5-5-5	3-4-4		0-1-1
Ha		1-1-1		1-1-2	2-3-5	8-9-11	5-5-8	0-0-4	2-3-6
Hb				1-1-4	2-4-7	8-9-12	6-8-10		1-2-4
Ib				0-1-1	1-4-4	4-9-9	1-8-8		0-2-3
K	1-1-2	0-1-1	1-1-2	1-2-3	1-2-3	2-4-5			
L	1-1-3	0-1-3	1-1-9	1-2-4	1-3-4	3-7-9		0-0-1	
N	0-1-1			0-2-3	0-1-1	0-3-4			
O	0-1-3		0-1-2	0-1-1	0-2-3	0-7-8	0-4-5	0-0-1	
Total species on *P. taxifolia*	1	1	1	3	5	12	10	0	3
all hosts	8	9	12	13	11	20	16	10	6

TABLE 12.—Lichens on *Alnus oregona*: data shown as in table 11.

Aa	0-1-1		1-2-2		0-1-1	0-5-6	0-3-5		
Ab	1-2-2		0-0-2	1-1-2	3-3-3	4-6-6	2-7-9	1-1-2	1-3-3
B	3-3-3		0-1-7	1-1-2	4-6-6	10-12-12	4-5-7	1-2-2	1-1-1
C	0-2-2		1-2-3	0-0-1	0-3-3	0-9-10	0-5-6	0-0-3	0-2-2
D	1-1-1				1-1-1	9-9-10	9-9-9		
Fa	1-2-2			1-1-2	3-4-4	0-9-9	1-2-4		0-0-1
Ha	0-0-2	0-1-1		0-0-2	0-5-5	4-11-11	2-4-8	0-2-4	0-3-6
Hb	1-1-2			0-2-4	7-7-7	7-11-12	2-3-3	1-3-7	1-3-4
J	2-2-2	1-1-1	0-2-5	2-2-2	6-7-7	10-10-10	1-3-3		0-1-1
K	1-2-2	0-1-1	1-1-2	0-1-3	0-3-3	0-4-5			
L	1-2-3	2-2-3	1-1-9	1-2-4	3-4-4	7-9-9		1-1-1	
M	1-1-1	0-0-1	1-2-3	1-2-2	1-2-2	1-7-8	0-3-4		1-1-1
O	3-3-3		0-0-2	1-1-1	3-3-3	2-8-8	0-5-5	1-1-1	
Total species on *A. oregona*	3	3	2	3	10	17	9	4	3
all hosts	8	9	12	13	11	20	16	10	6

which, in proper climatic conditions, favor the existence of particular epiphyte classes? To what extent have species been withheld by historic factors from biotically and climatically favorable areas? What role does microclimate play?

One of the main macroclimatic factors can scarcely be other than mean annual rainfall. Among the possibilities as a second major climatic factor the short time variation in gaseous or liquid water at the epiphyte's surface seem to be fairly likely, considering the familiar differences between lichens and other epiphytes in resistance to desiccation. A remoter possibility, perhaps, is liquid water at the epiphyte's surface at the time of the release of spores, gametes or other reproductive structures: either the mean annual value, or the

TABLE 13.—Lichens on *Picea sitchensis:* data shown as in table 11.

Aa	0-1-1		0-2-2		0-1-1		0-5-5		
Ab	1-2-2		1-1-2	1-2-2		0-3-6	5-7-9	0-1-2	2-3-3
B	1-2-3		1-5-7	1-2-2	1-2-6	6-11-13	2-6-7		0-1-1
C	2-2-2				2-2-3	9-9-10	5-6-6	3-3-3	1-2-2
D	0-1-1		2-3-3		0-1-1	3-8-10	4-6-9		
Ha				0-1-2	1-1-5	3-5-11	0-5-8	0-2-4	0-2-6
Ia	0-1-3					6-6-9	1-2-2	0-2-4	0-3-3
J	0-2-2		3-3-5	0-1-2	0-2-7	0-9-10	0-3-3		
K	1-2-2		1-1-2	1-2-3	1-1-3	4-5-5			
L	1-2-3		2-3-9	1-3-4	0-1-4	0-8-9			
M	0-1-1	1-1-1	3-3-3	1-2-2	1-2-2	5-6-8	3-4-4		1-1-1
O				0-1-2	2-2-3	0-7-8	0-5-5		
Total species on *P. sitchensis*	2	1	6	4	3	15	10	3	3
all hosts	8	9	12	13	11	20	16	10	6

TABLE 14.—Lichens on *Tsuga heterophylla:* data shown as in table 11.

Aa	0-1-1				1-1-1	6-6-6	6-6-6		
Ab	1-2-2			1-1-2		2-4-6	5-5-9		0-1-3
B	2-2-3		1-1-7	1-2-2	3-3-6	8-14-14	2-7-7		1-1-1
C	2-2-2			1-1-1	0-2-3	6-9-10	3-5-6		0-1-2
Fa	1-2-2			0-1-2	1-3-4	5-9-9	1-4-4		0-1-1
Fc				1-2-2		0-5-5	0-4-4		0-1-1
G				0-1-2	1-2-5	6-9-10	4-4-4		1-1-1
Ib				0-1-1	0-2-4	5-8-9	2-7-8		0-1-3
J	0-2-2				0-2-7	0-9-10	0-3-3		
K	0-2-2		0-1-2	1-2-3	0-2-3	0-5-5			
L	1-2-3		1-1-9	1-1-4	1-3-4	7-8-9			
M	0-1-1			0-1-2	0-2-2	0-7-8	0-3-4		0-1-1
N	1-1-1			0-2-3	0-1-1	0-3-4			
O	0-2-3		1-1-2	1-1-1	0-2-3	0-7-10	0-4-5		
Total species on *T. hetero.*	2	0	1	4	3	15	9	0	2
all hosts	8	9	12	13	11	20	16	10	6

extremes of year-to-year variation. To this the lichens should probably be more tolerant. Therefore the coast-high coordinate of figs. 8-11 might be a desiccation scale and the special rain-fog coordinate could be mean annual rainfall. This whole matter, however, requires further investigation.

Concerning the host-surface characteristics that are important in receptivity to epiphytes generally or to classes separately, it would seem that some information should be obtainable from a rather detailed comparison of 1) surface histology rather than morphology among hosts and 2) attachment and mineral-acquiring mechanisms among epiphytes.

In these and many other respects, epiphyte distribution offers a wide variety of fascinating, though perhaps not simple, problems in a rather general kind of biology.

REFERENCES

BAILEY, V. L. AND H. E. BAILEY 1949—Woody Plants of the Western National Parks. The American Midland Naturalist Monograph No. 4, The University Press, Notre Dame, Indiana.

BROWN, B. I. 1948—A Study of the distribution of epiphytic plants in New York. Amer. Midl. Nat. 39(2):457-497.

JONES, G. N. 1936—A Botanical Survey of the Olympic Peninsula, Washington. University of Washington Publications in Biology vol. 5. Seattle, Washington.

PIPER, C. V. 1906—Flora of the State of Washington. Vol. XI, Contributions from the United States National Herbarium, Smithsonian Institution, United States National Museum. Gov't. Printing Office, Washington, D. C.

SARGENT, C. S. 1921—Manual of the Trees of North America. Constable and Co. Ltd. The Riverside Press, Cambridge, Massachusetts.

SUMMARY

On 43 species of conifers, hardwoods and shrubs at 20 stations in 6 types of environment on the Olympic Peninsula in western Washington, a total of 195 species, varieties and forms of epiphytes have been found: 105 lichens, 36 liverworts, 48 mosses, 1 lycopsid and 5 ferns.

The total body of information obtained includes the identity of host species present and examined, the identity of epiphytes found in each host and the location of the epiphyte on the host at each of the collecting stations.

An analysis of these raw data was made to ascertain some general information regarding factors that control epiphyte distribution, at least on the Olympic Peninsula, the three main types of relevant variable being biotic, climatic and historic.

The distribution of hosts may be summarized by habitats in a two-dimensional arrangement with rain and high forest, coast and dry forest as pairs of extreme opposites and the distribution of the classes of epiphytes, lichens, liverworts and mosses, fall into the same pattern.

The stations can be arranged in such spatial relations in a plane that the number of epiphyte species per station varies in a simple, orderly fashion, the lichen, liverwort and moss frequencies each decreasing outward, and fairly symmetrically, from a central peak. The two-dimensionality of these figures suggests that the differences in suitability for epiphyte existence among areas of the Olympic Peninsula might be chiefly in two variables. Lichens appear to be able to tolerate a broader range of one variable x than of another, y; mosses

TABLE 15.—Proportion of hosts' potential lichen epiphytes at each station that are found on the host there.

Host*	M	Ab	B	L	O	K	Aa	J	Fa	N	E	Hb	Ib	Ha	Ia	C	D	Fc
1			0	0	0		.33			0		1.00				0		
2						1.00			0		0	.33		.89				
4	.75	.55	.43	.27	.07	.73	0	.10						.16	.54	.96	.47	
6										1.00			0					
7				.40	0	.55			.62	0	.37	.78	.26	.95				1.00
8	0	.62	.64	.73	.12	.08	1.00	0	.40	.14			.37			.57		.08
11			.06	.10	.33	0	0					0	.56	1.00		.15		.50
13				.91	.43	.27		0			.56	0						
14								.70							.73			
15		1.00	0					0						.54				
16					0			.33	.62		.15	.61	.67					
19	.35	.59	.80	.76		.17	.09	.79	.31			.63		.22		0	1.00	
23									.40		.84	.10						
25									.92		.13	.35	.73	.50				
28									.82		0	.36	.64					
29	0	.21	0		1.00		0	0	0						.73	.13		
33				0	0	0		0	0		0			1.00				

* For code to host identity, see table 2.
At station Fb host 7 had 1.00 of its potentials; at G, 6 and 8 each had .86.

about equal ranges and liverworts, wider differences of y than x. Since x and y appear as rectangular coordinates lying obliquely in the figures while the hosts and competitors are distributed on roughly polar coordinates, then x and y would seem more probably to be climatic.

The distribution of epiphytes among hosts was studied by means of relative receptivity which is fairly independent of climates at the stations where the host appears. The eleven gymnosperms, on the whole, are more receptive than the thirty-two angiosperms, only a few hosts apparently being more receptive to one class of epiphytes than to another.

It is not readily apparent what characteristics of the hosts determine their wide differences in total receptivity, but these seem to operate rather comparably on different family groups of lichens.

To disentangle biotic and climatic variables the station distribution of potential epiphytes for each host was examined for lichens, the only class having sufficient species. This was done for four host species and indicates a strong host-station interaction. Hosts vary more in general receptivity for lichens than in suitability for particular family groups. Host-station interaction was then examined in terms of the proportion of total lichen epiphytes present at a given station, that actually occur on each particular host there. This shows host differences in receptivity, station differences that are due to climatic factors and host-station interactions.

Presence of an epiphyte on a given host at a given station depends on the surface conditions of the given host, suitable climatic conditions, chiefly 2 variables, presence of at least one suitable host at a given station and previous opportunity for a given epiphyte to arrive at a given station.

APPENDIX A

Host Index

GYMNOSPERMAE

TAXACEAE

1. *Taxus brevifolia* Nutt. — LICHENS: 117 Aa; 146, 148, 152, 157, 160, 163, 165, 169, 185, 186, 187 Hb; HEPATICAE: 7, 10, 11, 12, 22, 23, 25, 26, 29, 31, 37 Aa; 7, 11, 12, 22, 25, 26, 31, 37 B; 37C; 29, 37 Hb; 26 L; 7, 12, 22, 24, 25, 31, 37 N; 7, 12, 21, 22, 25, 26, 31, 37 O; MUSCI: 43, 59, 69, 70, 74, 77, 88 Aa; 43, 72, 74, 85, 88 B; 74 C; 74, 85 Hb; 43, 68, 74 N; 43, 72 O; PTERIDOPHYTA: 2 Aa; 2 B; 2, 6 N.

PINACEAE

2. *Abies grandis* Lindl.—LICHENS: 136, 137, 141, 146, 148, 177, 186, 187 Ha; 165, 186, 187 Hb; 91, 137 K; HEPATICAE: 32, 37 Fa; 33 Ha; 10, 16, 26, 29 K; MUSCI: 69 Aa; 67, 74 E; 67 Fa; 43, 67, 74, 76, 77, 85 K.

3. *Abies lasiocarpa* (Hook.) Nutt. — LICHENS: 120, 135, 137, 138, 148, 149, 150, 156, 159, 160, 182 G; HEPATICAE: 8, 9, 20 G; MUSCI: 43, 61, 75 G.

4. *Picea sitchensis* (Bong.) Carr. — LICHENS: 95, 110, 119, 163, 165, 169, 170, 172, 186, 187 Ab; 91, 107, 108, 120, 135, 137, 148, 149, 150, 151, 154, 159, 160 B; 91, 95, 128, 134, 135, 137, 139, 142, 143, 148, 150, 151, 154, 155, 163, 167, 169, 170, 171, 173, 176, 181, 183 C; 112, 117, 139, 144, 153, 163, 167, 169, 171 D; 137, 148, 154 Ha; 137, 145, 148, 153, 154, 155, 157 Ia; 108, 116, 117 J; 95, 125, 128, 137, 139, 148, 150 K; 91, 107, 117, 125g L; 106, 108, 116, 117, 125, 128, 137, 138, 139, 153, 154, 165, 167, 169, 187 M; 107 O; HEPATICAE: 18, 36, 37 Ab; 11, 29, 37 B; 36 C; 36, 37 D; 26, 32 J; 37 K; 8, 13, 16, 25, 26 L; 10, 26, 36, 37 M; 25, 26, 29, 36 O; MUSCI: 67, 74 Ab; 43, 54, 74, 88 B; 43, 55, 74, 85, 88 C; 55, 59, 68, 74 D; 74 J; 59, 69, 74 K; 43, 69, 70, 72, 74, 77, 88 L; 55, 68, 74, 77 M; 43, 67, 68, 73, 74, 76, 77, 85, 88; PTERIDOPHYTA: 2 Aa; 1 Ab; 2 B; 2 C; 2 J; 2, 6 L; 1, 2, 3, 4 M; 2 O.

5. *Pinus contorta* Dougl. — LICHENS: 125 N; HEPATICAE: 14, 26, 37 N; MUSCI: 43, 67, 69, 70, 72, 74, 77 N.

6. *Pinus monticola* Dougl.—LICHENS: 119, 136, 137, 149, 150, 152, 153, 155, 156, 159, 160, 182 G; 91, 120, 121, 125, 128, 137, 144, 150, 154 N; HEPATICAE: 7, 10, 12, 13, 15, 16, 16a, 25, 26, 35, 37 N; MUSCI: 67 Ib; 43, 67, 69, 70, 71, 72, 74, 88 N.

7. *Pseudotsuga taxifolia* (Lamb.) Britt. —LICHENS: 91, 125, 127, 137, 150, 153, 154, 160 E; 91, 125, 127, 128, 135, 137, 145, 148, 149, 150, 154, 160, 172 Fa; 159 Fb; 120, 125, 137, 149, 150, 154, 155, 158, 160, 171, 182 Fc; 99, 125, 126, 134, 141, 145, 146, 147, 148, 150, 154, 157, 163, 168, 169, 172, 186, 187 Ha; 125, 126, 134, 137, 145, 146, 147, 148, 150, 153, 154, 157, 159, 167, 168, 169, 172, 187 Hb; 127, 137, 146, 150, 154, 169 Ib; 91, 107, 125g, 127, 137, 151 K; 91, 107, 125g, 127, 137, 150, 151 L; HEPATICAE: 32, 37 Fa; 8, 9, 20 Fc; 26, 37 K; 11, 13, 26 L; 29, 37 N; 11, 13, 26, 37 O; MUSCI: 42, 43, 56, 67, 72, 74 E; 42, 43, 67, 72, 74, 85 Fa; 43, 72, 73, 75 Fc; 42, 74 Ha; 42, 44, 72, 80, 83 Hb; 43, 72, 74, 88 K; 72, 73, 74, 88 L; 74, 85, 88 N; 67, 72, 74, 77, 85, 88 O; PTERIDOPHYTA: 2, 6 L; 2, 3 O.

8. *Tsuga heterophylla* (Raf.) Sarg.— LICHENS: 120, 135, 137, 139, 146, 147, 150, 154, 159, 160, 167, 168, 169, 172 Aa; 91, 142, 143, 163, 167, 168, 169, 172 Ab; 91, 95, 107, 120, 127, 128, 135, 137, 138, 139, 146, 149, 150, 151, 153, 154, 160, 172, 187 B; 91, 95, 125f, 137, 139, 150, 151, 154, 163, 169, 172 C; 91, 135, 137, 146, 148, 150, 155, 160 Fa; 120 Fc; 128, 137, 146, 148, 150, 153, 155, 158, 159, 160, 171, 182 G; 137, 145, 150, 154, 155, 160, 171 Ib; 125b K; 91, 107, 125, 128, 137, 143, 146, 149, 150, 151, 154 L; 91 N; 107, 125 O; HEPATICAE: 11, 13, 16, 25, 26 Aa; 36, 37 Ab; 11, 26, 37 B; 26, 37 C; 33 Fa; 8 Fc; 26 J; 24 K; 8, 9, 26, 37 L; 18, 26, 36, 37 M; 37 N; 12, 16, 22, 23 O; MUSCI: 43, 60, 70, 74, 77, 82 Aa; 43, 54, 74, 77, 88 B; 43, 69, 72, 74 C; 67, 72 Fa; 72 Fc; 43, 67, 74 J; 69, 72, 74, 88 L; 74, 88 M; 74 N; 63, 67, 88 O; PTERIDOPHYTA: 2, 3, 4, 5 Aa; 1 Ab; 2 B; 1 C; 6 J; 2 K; 6 L; 3 O.

9. *Tsuga mertensiana* (Bong.) Carr.— No epiphytes.

10. *Chamaecyparis nootkatensis* (Lamb.) Spach.—LICHENS: 101, 106, 119, 120, 128, 132, 133, 135, 146, 149, 150, 155, 156, 159, 160, 179, 182 G; MUSCI: 64, 71 G.

11. *Thuja plicata* Donn. — LICHENS: 91 B; 91, 169 C; 158, 159, 160 Fc; 126, 128, 132, 134, 136, 137, 141, 145, 148, 150, 155, 157, 165, 169, 173, 174, 186, 187 Ha; 128, 137, 145, 146, 148, 150, 153, 154, 167, 186 Ib; 125g L; 91, 125, 128, 135 O; HEPATICAE: 11, 12, 26 Aa; 7, 11, 26, 37 B; 10, 26, 37 C; 18 Ha; 26 K; 26 L; 11, 25, 26, 37 O; MUSCI: 43, 54, 59, 72, 74, 77, 88 B; 43, 67, 72, 74, 77 C; 67 Fc; 44 Ha; 74 Hb; 74, 77 K; 69, 72, 74 L; 58, 67, 69, 72, 74, 77, 85, 88 O; PTERIDOPHYTA: 2 B; 1 C; 6 L.

ANGIOSPERMAE

SALICACEAE

12. *Populus tremuloides* Michx. — LICHENS: 130, 141, 162, 163, 174, 183 E; HEPATICAE: 18, 29, 33, 36 E; MUSCI: 2, 47, 48, 50, 58, 60, 63, 65, 67, 68, 74, 85, 86, 88, 89 E.

13. *Populus trichocarpa* T. & G. — LICHENS: 101, 102, 104, 111, 115, 118, 128, 134, 141, 148 E; 99, 109, 133 K; 91, 95, 100, 107, 110, 111, 113, 114, 118, 119, 122, 125, 128, 133, 135, 137, 144, 146, 148, 150, 151 L; 118, 128, 135, 144, 148 O; HEPATICAE: 29 E; 26, 29, 37, 38, 41 J; 38 K; 17, 27, 29, 32, 37, 38 L; 29, 37, 38 O; MUSCI: 48, 63, 65, 73, 74, 85, 86, 88, 89 E; 44, 58, 68, 69, 70, 73, 82, 85 J; 67, 74 K; 60, 63, 65, 69, 70, 73, 74, 85, 86, 88 L; 44, 48, 54, 59, 63, 65, 67, 69, 70, 73, 85, 88 O; PTERIDOPHYTA: 2, 6 J; 2, 6 K; 2, 6 L; 2, 6 O.

14. *Salix lasiandra* Benth. — LICHENS: 124, 130, 141, 146, 163, 174, 176, 183 Ia; 95, 103, 115, 118, 128, 131, 186 J; HEPATICAE: 33 Ia; 29, 37 J; MUSCI: 46 Ia; 48 63, 66 J; PTERIDOPHYTA: 2 J.

15. *Salix scouleriana* Barratt.—LICHENS: 95, 115, 119, 131, 136, 140, 141, 142, 148, 162, 163, 167, 169, 171, 172, 173 Ab; 137, 145, 147, 148, 150, 155, 163 Ha; HEPATICAE: 33, 36 Ab; 36 B; 29 Ha; 29 J; MUSCI: 55, 68, 74, 85, 88 Ab; 74, 88 Ha; 47, 49 J; PTERIDOPHYTA: 2 Ab; 2 B.

16. *Salix sitchensis* Sanson.—LICHENS: 134, 163, 174 E; 126, 135, 137, 145, 146, 154, 160, 172 Fa; 119, 134, 136, 140, 141, 145, 148, 157, 163, 164, 167, 169, 173, 174, 175, 180, 186 Hb; 126, 134, 137, 141, 145, 148, 150, 154, 157, 159, 160, 163, 168, 169, 186, 187 Ib; 151, 154, 163, 168, 169 J; HEPATICAE:37 E; 29, 32, 33, 37 Fa; 29 Hb; 29,32, 37 O; MUSCI:48, 65, 67, 73, 74 Fa; 74 Hb; 67 Ib; 65 J; 60, 63, 64, 65, 73, 85, 86 O; PTERIDOPHYTA: 2 O.

JUGLANDACEAE

17. *Juglans nigra* L.—LICHENS: 96, 125a, 129, 136, 141, 145, 148, 155, 157, 163, 173, 175, 176, 186 Ia; MUSCI: 63, 68 Ia.

BETULACEAE

18. *Corylus californica* (A. DC.) Rose.—LICHENS: 119, 126, 131, 134, 136, 140, 141, 145, 146, 147, 148, 150, 153, 163, 167, 169, 175, 175a, 176, 177, 183, 187 Hb; HEPATICAE: 29, 37 Hb; MUSCI: 48, 67, 68, 78, 85, 88 Hb.

19. *Alnus oregona* Nutt.—LICHENS: 116 Aa; 95, 119, 131, 132, 136, 141, 142, 146, 148, 163, 169, 174, 183 Ab; 91, 92, 95, 125, 126, 128, 133, 135, 137, 144, 146, 147, 148, 150, 151, 153, 154, 155, 167, 168, 169, 171, 177, 187, B; 95, 116, 135, 140, 142, 144, 145, 146, 148, 150, 153, 154, 160, 162, 163, 166, 167, 168, 169, 170, 171 D; 95, 125, 127, 128, 135, 168 Fa; 137,138, 148,155, 157, 169 Ha; 95, 126, 128, 131, 133, 134, 135, 136, 140 144, 145, 148, 149, 150, 153, 163, 169, 175, 177, 186 Hb; 91, 95, 103, 119, 125e, 126, 128, 130, 133, 134, 135, 137, 143, 144, 145, 146, 148, 150, 151, 154, 155, 169 J; 95, 117 K; 95, 98, 99, 117, 125, 128, 133, 135, 137, 144, 148, 149, 150, 151, 154, 177 L; 95, 116, 119, 135, 148, 187 M; 91, 92, 95, 125, 128, 133, 135, 144, 151, 178 O; HEPATICAE: 29, 37 Aa; 29, 32, 37, 38 B; 32, 37 C; 37 D; 29, 32 Fa; 24, 26, 29, 32, 36, 37, 38 J; 32, 37 K; 29, 37 L; 11, 18, 32, 36, 37, 38 M; 29, 32, 37, 38, 40 O; MUSCI: 43, 48, 54, 55, 67, 68, 74 Aa; 43, 68, 74 Ab; 43, 54, 67, 68, 74, 85, 88 B; 68, 74 C; 59, 74 D; 43, 67 Fa; 74, 88 Ha; 68 Hb; 43, 44, 48, 51, 54, 55, 58, 59, 69, 70, 73, 74, 77, 82, 83, 85, 88 J; 48, 49, 54, 67, 69, 85 K; 43, 47, 48, 54, 69, 73, 74, 76, 85, 88 L; 55, 67, 74, 77, 83, 84, 85 M; 43, 47, 48, 51, 54, 59, 65, 67, 69, 71, 73, 74, 83, 85, 88 O; PTERIDOPHYTA: 2 Aa; 2 B; 1, 2, C; 2 D; 2, 4, 6, J; 2, 4, 6 K; 2, 6 L; 1, 2 M; 2, 6 O.

FAGACEAE

20. *Fagus sylvatica* L.—LICHENS: 105, 108, 110, 114, 116, 118, 128, 134, 135, 148, 150, 174, 177 B; HEPATICAE: 29, 32, 33, 37 B; MUSCI: 48, 49, 51, 55, 74, 85 B.

21. *Quercus garryana* Dougl.—LICHENS: 97, 126, 145, 148, 150, 153, 154, 157, 163, 164, 169, 175, 186 Hb; MUSCI: 46, 63, 65, 85, 86 Hb.

SAXIFRAGACEAE

22. *Ribes sanguineum* Pursh.—LICHENS: 134, 136, 164, 173, 177, 187 Hb.

ROSACEAE

23. *Amelanchier florida* Lindl.—LICHENS: 119, 126, 131, 134, 137, 140, 145, 146, 148, 149, 150, 151, 155, 157, 163, 169, 173, 174, 177, 180, 181 E; 123, 127, 128, 135, 150, 154 Fa; 134, 136 Hb; HEPATICAE: 29, 32 Fa; MUSCI: 60, 73, 86 E; 47, 48, 67, 69, 71, 73, 74, 85 Fa.

24. *Crataegus douglasii* Lindl.—LICHENS: 174, 176 Hb; HEPATICAE: 18, 33 E; MUSCI: 47, 48, 68, 74, 85 E.

25. *Holodiscus discolor* (Pursh.) Maxim.—LICHENS: 126, 145, 148 E; 128, 135, 137, 145, 146, 148, 149, 150, 154, 155, 169 Fa; 128, 134, 145, 148, 155, 157, 169 Ha; 128, 134, 136, 157, 163, 177 Hb; 126, 145, 148, 150, 154, 155, 159, 160, 163, 169, 186 Ib; HEPATICAE: 29, 32, 37 E; 19, 28, 29, 31, 32, 33, 34, 37 Fa;MUSCI: 67, 74 E; 67, 85 Fa.

26. *Osmaronia cerasiformis* (T. & G.) Greene.—HEPATICAE: 37 J; 36 K; MUSCI: 69, 74, 85 J; 74, 88 K; PTERIDOPHYTA: 6 J.

27. *Prunus domestica* L.—LICHENS: 95, 108, 141, 147, 148, 154, 163, 169 M.

28. *Prunus emarginata* (Dougl.) Walp.—LICHENS: 91, 145, 146, 150, 151, 154, 155, 160, 182 Fa; 145, 148, 163, 165 Hb; 141, 145, 148, 154, 155, 169, 185 Ib; HEPATICAE: 29, 32, 37 Fa; 17 Hb; MUSCI: 67, 74, E; 67, 72, 85 Fa; 68 Hb.

29. *Pyrus diversifolia* Bong.—LICHENS: 142, 163, 169 Ab; 169, 187 C; 94, 95, 124, 131, 136, 140, 141, 148, 163, 186, 187 Ia; 125, 128, 133, 135, 137, 144, 146, 148, 150, 151, 154, 155, 160, 168, 169, 170, 171 O; HEPATICAE: 24, 36, 37 Aa; 36, 37 Ab; 11, 22, 23, 29, 36, 37 B; 37 C; 29, 32, 33 Fa; 10, 18, 26 L; 36, 37 M; 18,

22, 26, 29, 31, 36, 37, 38, O; MUSCI: 43, 48, 54, 55, 67, 74, 88 Aa; 43, 55 Ab; 43, 54, 74, 88 B; 74 C; 53, 62, 65, 66, 67, 71, 72, 73, 74, 85 Fa; 67, 74 Ia; 67, 69 J; 59, 73, 74 L; 54, 67, 74 M; 43, 44, 48, 55, 59, 67, 69, 73, 74, 85, 88 O; PTERIDOPHYTA: 2, 6 B; 2 C; 2, 6 L; 2 M; 2, 6 O.

30. *Rubus spectabilis* Pursh.—MUSCI: 68 M.

ACERACEAE

31. *Acer circinatum* Pursh.—LICHENS: 90, 99, 115 L; 133 O; HEPATICAE: 37, 41 J; 29, 31, 37 K; 26, 29, 31, 32, 39 L; 29, 31, 33, 38 O; MUSCI: 59, 67, 68, 73, 74, 82, 88 J; 58, 69, 74, 88 K; 44, 65, 66, 69, 70, 71, 73, 74, 82, 85 L; 43, 48, 54, 69, 73, 74, 82, 85, 88 O; PTERIDOPHYTA: 2, 6 J; 2 K; 6 L; 6 O.

32. *Acer glabrum* Torr. — LICHENS: 119, 128, 131, 135, 137, 149 E; 125, 127, 128, 135, 137, 168 Fa; HEPATICAE: 29, 32, 37 Fa; MUSCI: 68 E; 64, 65, 67, 74, 85 Fa.

33. *Acer macrophyllum* Pursh. — LICHENS: 93, 97, 124, 125, 134, 140, 141, 148, 157, 161, 162, 164, 165, 175, 176, 182, 183, 184, 185, 186, 187 Ha; HEPATICAE: 29 E; 29, 32, 34 Fa; 29, 38 J; 37, 41 K; 29, 31, 38, 41 L; 29, 37, 38 O; MUSCI: 48, 67, 71, 73, 74, 85, 88 E; 65, 85 Fa; 45, 57, 63, 79, 80, 87 Ha; 58, 67, 69, 70, 73, 82, 85 J; 70, 74, 82, 88 K; 58, 60, 65, 69, 71, 73, 74, 78, 82, 86 L; 48, 54, 59, 60, 63, 65, 67, 71, 73, 74, 82, 85, 88 O; PTERIDOPHYTA: 2, 3, 6 J; 2, 6 K; 2, 6 L; 2, 3, 6 O.

34. *Acer platanoides* L.—HEPATICAE: 37 B; MUSCI: 74, 85 B.

HIPPOCASTANACEAE

35. *Aesculus hippocastanum* L. — LICHENS: 106, 108, 112, 118, 125 B; HEPATICAE: 29, 32, 37 B; MUSCI: 54 B.

RHAMNACEAE

36. *Rhamnus purshiana* DC.—LICHENS: 95 Aa; HEPATICAE: 24, 37, 38 Aa; 37, 39 Ab; 37 C; 37 J; 18, 31, 32, 37 L; 31, 37 N; 7, 32, 37, 38 O; MUSCI: 43, 48, 54, 67, 68, 74, 85 Aa; 43, 75, 77 Ab; 55, 74 C; 74 J; 67 K; 43, 59, 67, 70, 73, 74, 88 L; 74, 88 N; 54, 59, 68, 74, 77 O; PTERIDOPHYTA: 2 C; 6 L.

CORNACEAE

37. *Cornus nuttallii* Audubon. — LICHENS: 128, 131, 137, 146, 149, 155 E; HEPATICAE: 29, 30, 32, 33, 34, 37 E; MUSCI: 52, 67, 85 E.

ERICACEAE

38. *Arbutus menziesii* Pursh.—LICHENS: 125b, 125c, 163 Hb; 125 Ib; HEPATICAE: 17, 32 Hb; MUSCI: 59, 67, 68, 73, 74 E; 67, 74 Hb; 67 Ib.

39. *Arctostaphylos tomentosa* (Pursh.) Lindl.—LICHENS: 145, 160, 168, 169 Ib.

40. *Rhododendron macrophyllum* Don. LICHENS: 134, 137, 141, 145, 148, 150, 153, 154, 155, 159, 160, 163, 167, 168, 169, 186 Ib; HEPATICAE: 37 Ib; MUSCI: 67 Ib.

CAPRIFOLIACEAE

41. *Lonicera involucrata* (Richards.) Banks.—LICHENS: 116 M; HEPATICAE: 36 M; MUSCI: 55, 68, 84 M.

42. *Sambucus callicarpa* Greene.—HEPATICAE: 28, 33, 36 Ab; 29, 39 J; MUSCI: 68, 81 Ab; 58, 60, 69, 82, 85 J; PTERIDOPHYTA: 2, 3 Ab; 2 J; 2 K.

43. *Sambucus glauca* Nutt.—LICHENS: 97, 134, 174, 186, 187 Hb.

APPENDIX B

Annotated list of the epiphytic plants

Summarized for each epiphyte: hosts by number, stations by letter, location on host

PTERIDOPHYTA

POLYPODIACEAE

1. *Polypodium scouleri* Hook and Grev. —4, 8, 11, 19; Ab, C, M; trunk, crotches of large branches.

2. *Polypodium vulgare* L.—1, 4, 7, 8, 11, 13, 14 15, 16, 19, 29, 31 33, 36, 42; Aa, Ab, C, D, J, K, L, M, N, O; trunk base, trunk, branches from lowest to those 100 feet high on certain hosts.

3. *Polystichum munitum* (Kaulf.) Presl.

—4, 7, 8, 33, 42; Aa, J, M, O; trunk, crotches.

4. *Athyrium felix-femina* (L.) Roth.—4, 8, 19; Aa, J, K, M; trunk.

5. *Struthiopteris spicant* (L.) Weis.—8; Aa; trunk.

SELAGINELLACEAE

6. *Selaginella oregana* D. C. Eaton.—1, 4, 7, 8, 11, 13, 19, 25, 29, 31, 33, 36; B, J, K, L, N, O; trunk, branches, at times to 100 feet elevation; very conspicuous in the Hoh and Quinault River valleys at low altitude.

BRYOPHYTA

MUSCI

DICRANACEAE

42. *Dicranweisia cirrata* (L.) Lindb.—7, 12; E, Fa, Ha, Hb; trunk.

43. *Dicranum fuscescens* Turn.—1, 2, 3, 4, 5, 6, 7, 8, 11, 19, 29, 31, 36; Aa, Ab, B, C, E, Fa,Fc, G, J, K, L, N, O; trunk base, trunk and branches to 100 feet or more.

44. *Dicranum scoparium* (L.) Hedw.—7, 11, 13, 19, 29, 31; Ha, Hb, J, L, O; trunk base, trunk, branches.

POTTIACEAE

45. *Tortula ruralis* (L.) Ehr.—33; Ha; trunk, large branches.

ORTHOTRICHACEAE

46. *Orthotrichum affine* Schrad. — 14, 21; Hb, Ia; trunk and branches.

47. *Orthotrichum consimile* Nutt. — 12, 15, 19, 23, 24; E, Fa, J, M, O; usually trunk.

48. *Orthotrichum lyellii* Hook. & Tayl. —12, 13, 14, 15, 16, 18, 19, 20, 23, 24, 29, 31, 33, 36; Aa, B, E, Fa, Hb, J, K, L, O; trunk and branches, often the upper.

49. *Orthotrichum pulchellum* Brunton.—15, 19, 20; B, J, K; trunk, branches.

50. *Orthotrichum speciosum* Nees. — 12; E; trunk base.

51. *Ulota bruchii* Hornsch.—19, 20; B, J, O; trunk.

52. *Ulota crispa* (Hedw.) Brid.—37; E; upper trunk, branches.

53. *Ulota megalospora* Vent.—29; Fa; trunk and branches.

54. *Ulota obtusiuscula* C. M. & Kindb. —4, 8, 11, 13, 19, 20, 29, 31, 33, 35, 36; Aa, B, J, K, L, M, O; trunk and branches, at times in both zones to a height of 100 feet.

55. *Ulota phyllantha* Brid.—4, 15, 19, 20, 29, 36, 41; Aa, Ab, B, C, D, J, M, O; trunk and branches.

AULACOMNIACEAE

56. *Aulacomnium androgynum* (L.) Schwaegr.—7; E; trunk base.

BRYACEAE

57. *Bryum capillare* L.—33; Ha; trunk.

58. *Mnium menziesii* C. M. — 11, 12, 13, 19, 31, 33, 42; E, J, K, L, O; usually trunk.

59. *Mnium punctatum* (L.) Hedw.—1, 4, 11, 13, 19, 29, 33, 36, 38; Aa, B, D, E, J, K, L, O; trunk and branches.

60. *Mnium venustum* Mitt.—8, 12, 13, 16, 23, 33, 42; Aa, E, J, L, O; usually trunk.

HYPNACEAE

61. *Brachythecium leibergii* Grout.—3; G; trunk base.

62. *Calliergonella schreberi* (Willd.) Br. & Sch. (Bry. Eur.) Grout.—29; Fa; trunk and branches.

63. *Camptothecium lutescens* (Huds.) Br. & Sch.—8, 12, 13, 14, 16, 17, 21, 33; E, Ha, Hb, Ia, J, L, O; usually trunk.

64. *Camptothecium megaptilum* Sull.—10, 16, 32; Fa, G, O; usually trunk.

65. *Camptothecium nuttallii* (Wils.) Br. & Sch.—12, 13, 16, 19, 21, 29, 31, 32, 33; E, Fa, Hb, J, L, O; trunk and branches, occasionally upper region of both zones.

66. *Camptothecium pinnatifidum* (Sull. & Lesq.) Jaeg. & Sauerb.—14, 29, 31; Fa, J, L; trunk and branches.

67. *Eurynchium oreganum* (Sull.) Jaeg. & Sauerb.—2, 4, 5, 6, 7, 8, 11, 12, 13, 16, 18, 19, 23, 25, 28, 29, 31 32, 33, 36, 37, 38, 40; Aa, Ab, B, C, E, Fa, Fc, Hb, Ia, Ib, J, K, L, M, N, O; trunk base, trunk, occasionally branches both low and high.

68. *Eurynchium stokesii* (Turn.) Br. & Sch.—1, 4, 12, 13, 15, 17, 18, 19, 24, 28, 30, 31, 32, 38, 41, 42; Aa, Ab, B, C,

D, E, Hb, Ia, J, M, N, O; trunk, sometimes branches.

69. *Hylocomium loreum* (L.) Br. & Sch.—1, 2, 4, 5, 6, 7, 8, 11, 13, 19, 23, 28, 29, 31, 33, 42; Aa, C, Fa, J, K, L, N, O; trunkbase, trunk, branches.

70. *Hylocomium proliferum* (L.) Lindb.—1, 4, 5, 6, 8, 13, 19, 31, 33, 36; Aa, J, K, L, N, O; trunk base, trunk usually, forming thick mats.

71. *Hylocomium triquetrum* (L.) Br. & Sch.—6, 10, 13, 19, 23, 29, 31, 33; E, Fa, G, K, L, N, O; trunk usually, occasionally branches.

72. *Hypnum circinale* Hook.—1, 4, 5, 6, 7, 8, 11, 13, 28, 29; B, C, E, Fa, Fc, Hb, J, K, L, N, O; usually trunk.

73. *Hypnum subimponens* Lesq.—4, 7, 13, 16, 19, 23, 29, 31, 33, 36, 38; E, Fa, Fc, J, L, O; trunk branches.

74. *Isothecium stoloniferum* (Hook.) Brid.—1, 2, 4, 5, 6, 7, 8, 11, 12, 13, 15, 16, 19, 20, 23, 24, 25, 26, 28, 29, 31, 32, 33, 34, 36, 38; Aa, Ab, B, C, D, E, Fa, Ha, Hb, Ia, J, K, L, M, N, O; trunk, trunk base, branches, on some hosts to 100 feet high.

75. *Plagiothecium denticulatum* (Hedw.) Bry. Eur.—3, 7, 36; Ab, Fc, G; trunk base, trunk.

76. *Plagiothecium piliferum* (Sw.) Br. & Sch.—2, 4, 19; K, L, O; trunk.

77. *Plagiothecium undulatum* (L.) Br. & Sch.—1, 2, 4, 5, 7, 8, 11, 19, 36; Aa, Ab, B, C, J, K, L, M, N, O; trunk base, trunk, branches.

78. *Scleropodium caespitosum* (Wils.) Br. & Sch.—18, 33; Hb, L; trunk.

79. *Scleropodium illecebrum* (Hedw.) Bry. Eur.—33; Ha; trunk.

80. *Tripterocladium brunwissianum* Lesq. & Fleisch.—7, 33; Ha, Hb; trunk base, trunk.

LESKEACEAE

81. *Claopodium bolanderi* Best. — 42; Ab; trunk and branches.

82. *Claopodium crispifolium* (Hook.) Ren. & Card.—8, 13, 19, 29, 31, 33, 42; Aa, J, K, L, O; trunk and occasionally branches.

83. *Heterocladium heteropteroides* Best.—7, 19; Hb, J, M, O; usually trunk.

HOOKERIACEAE

84. *Hookeria lucens* (L.) Sm.—19, 41; M; trunk base, trunk.

NECKERACEAE

85. *Neckera douglasii* Hook.—1, 2, 4, 7, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 23, 24, 25, 26, 28, 29, 31, 32, 33, 34, 36, 37, 42; Aa, Ab, B, C, E, Fa, Hb, J, K, L, M, N, O; trunk and branches from base to top, forming dense mats.

86. *Neckera menziesii* Hook. & C. M.—12, 13, 16, 21, 23, 33; E, Hb, L, O; trunk usually; may form large mats 10 inches long.

CRYPHACEAE

87. *Alsia californica* (Hook. & Arn.) Sull.—33; Ha; trunk.

88. *Antitrichia curtipendula* (Hedw.) Brid.—1, 4, 6, 7, 8, 11, 12, 13, 15, 18, 19, 26, 29, 31, 33, 36; Aa, Ab, B, C, E, Ha, Hb, J, K, L, M, N, O; trunk and branches, on some hosts to height of 100 feet.

89. *Dendroalsia abietina* (Hook.) E. G. Britton.—12, 13; E; trunk.

HEPATICAE

PTILIDIACEAE

7. *Herberta hutchinsiae* (Gottsche) Evans.—1, 6, 11, 36; Aa, B, N, O; trunk usually, occasionally upper branches.

8. *Ptilidium californicum* (Aust.) Underw. & Cook.—3, 4, 7, 8; Fc, G, L; trunk base, trunk and upper branches.

9. *Ptilidium pulcherrimum* (Weber) Hampe.—3, 7, 8; Fc, G, L; lower trunk and upper trunk at height of 100 feet.

10. *Blepharostoma trichophyllum* (L.) Dumort.—1, 2, 4, 6, 11, 29; Aa, C, K, L, M, N; trunk base and trunk.

LEPIDOZIACEAE

11. *Bazzania ambigua* (Leudenb.) Trev.—1, 4, 7, 8, 11, 19, 29; Aa, B, L, M, O; trunk base, trunk, branches, at times to height of 100 feet.

12. *Bazzania tricrenata* Wahl.—1, 6, 8, 11; Aa, B, N, O; trunk usually.

13. *Lepidozia reptans* (L.) Dum.—4, 6, 7, 8; Aa, L, N, O; trunk base and trunk.

CALYPOGEIACEAE

14. *Calypogeia trichomanes* (L.) Corda.—5; N; usually trunk.

CEPHALOZIACEAE

15. *Cephalozia leucantha* Spruce. 6; N; trunk.

16. *Cephalozia media* Lindb.—2, 4, 6, 8; Aa, K, L, N, O; trunk base and trunk.

16.1. *Odontoschisma denudatum* Nees.—6; N; trunk.

HARPANTHACEAE

17. *Lophocolea bidentata* (L.) Dum.—13, 28, 38; Hb, L; trunk base and trunk.

18. *Lophocolea cuspidata* (Nees.) Limpr.—4, 8, 11, 12, 19, 24, 29, 36; Ab, E, Ha, L, M, O; trunk base, trunk, branches.

19. *Lophocolea heterophylla* (Schrad.) Dumort.—25; Fa; trunk.

JUNGERMANNIACEAE

20. *Lophozia ventricosa* (Dicks.) Dumort.—3, 7; Fc, G; trunk.

PLAGIOCHILACEAE

21. *Plagiochila adiantoides*.—1; O; upper branches.

22. *Plagiochila asplenioides* (L.) Dum.—1, 8, 29; Aa, B, N, O; trunk.

SCAPANIACEAE

23. *Diplophyllum albicans* (L.) Dum.—1, 8, 29; Aa, B, O; trunk.

24. *Diplophyllum ovatum* (Dicks.) Steph.—1, 8, 19, 29, 36; Aa, J, K, N; trunk usually.

25. *Diplophyllum plicatum* Lindl.—1, 4, 6, 8, 11; Aa, B, L, N, O; usually trunk.

26. *Scapania bolanderi* Aust.—1, 2, 4, 5, 6, 7, 8, 11, 13, 19, 29, 31; Aa, B, C, J, K, L, M, N, O; trunk base, occasionally trunk.

27. *Scapania undulata* (L.) Dum.—13; L; trunk.

PORELLACEAE

28. *Porella cordaeana* (Hueb.) Evans.—25, 42; Ab, Fa; trunk and slanting branches.

29. *Porella navicularis* (Lemm. & Lindenb.) Lindb.—1, 2, 4, 7, 12, 13, 14, 15, 16, 18, 19, 20, 23, 25, 28, 29, 31, 32, 33, 34, 37, 42; Aa, B, E, Fa, Ha, Hb, J, K, L, M, O; trunk, branches, often to height of 100 feet.

30. *Porella platyphylloidea* (Schwein) Lindb.—37; E; trunk.

31. *Porella roellii* Steph.—1, 25, 29, 31, 33, 36; Aa, B, Fa, K, L, N, O; trunk and branches.

RADULACEAE

32. *Radula bolanderi* Gottsche.—2, 4, 7, 13, 16, 19, 20, 23, 25, 28, 29, 31, 32, 35, 36, 37, 38; B, C, E, Fa, Hb,J, K, L, M, O; trunk, occasionally on upper part, and branches.

33. *Radula complanata* (L.) Dum.—2, 8, 12, 14, 15, 16, 20, 24, 25, 29, 31, 37, 42; Ab, B, E, Fa, Ha,Ia,O; trunk base, trunk, occasionally branches.

FRULLANIACEAE

34. *Frullania bolanderi* Aust.—25, 33, 37; E, Fa; trunk.

35. *Frullania californica* (Aust.) Evans.—6; N; trunk.

36. *Frullania franciscana* Howe.—4, 7, 8, 12, 15, 19, 26, 29, 41, 42; Aa, Ab, B, C, D, E, J, K, M, O; trunk and branches.

37. *Frullania nisquallensis* Sull.—1, 2, 4, 5, 6, 7, 8, 11, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 31, 32, 33, 34, 35, 36, 37, 40; Aa, Ab, B, C, D, E, Fa, Hb, Ib, J, K, L, M, N, O; trunks and branches, often at 60-100 feet elevation, also branchlets and leafy twigs.

METZGERIACEAE

38. *Metzgeria conjugata* Lindb.—13, 19, 29, 31, 33, 36; Aa, B, J, K, L, M, O; chiefly trunk.

39. *Metzgeria fruticulosa* (Dickson) Evans.—31, 36, 42; Ab, J, L; trunk.

40. *Metzgeria furcata* (L.) Dum.—19; O; trunk.

41. *Metzgeria pubescens* (Schrank) Raddi.—13, 31, 33; J, K, L; trunk.

THALLOPHYTA

FUNGI

ASCOLICHENS

PYRENULACEAE

90. *Pyrenula laevigata* (Pers.) Arn.—31; L; trunk and branches.

108. *Lobaria pulmonaria* (L.) Hoffm.—4, 20, 27, 35; B, J, M; trunk and branches.

109. *Lobaria verrucosa* (Huds.) Hoffm.—13; L; upper trunk and branches.

110. *Sticta anthraspis* Ach.—4, 13, 20; Ab, B, L; trunk and upper branches.

111. *Sticta fuliginosa* (Dicks.) Ach.—13; E, L; trunk and branches, often the upper.

112. *Sticta limbata* (Sm.) Ach.—4, 35; B, D; trunk.

113. *Sticta quercizans* Ach.—13; L; upper trunk and branches.

114. *Nephroma lusitanicum* Schaer.—13, 20; B, L; trunk and branches.

115. *Nephroma resupinatum* (L.) Ach.—13, 14, 15, 31; Ab, E, J, L; trunk and branches.

PELTIGERACEAE

116. *Peltigera membranacea* (Ach.) Nyl. emend. Thoms.—4, 19, 20, 41; Aa, B, D, J, M; trunk and branches.

117. *Peltigera polydactyla* (Neck.) Hoffm. var. *typica*.—1, 4, 19; Aa, D, J, K, L, M; trunk, occasionally branches.

118. *Peltigera scutata* (Dicks.) Duby.—13, 14, 20, 35; B, E, J, L, O; trunk and branches, occasionally upper in both zones, with mosses.

LECIDEACEAE

119. *Lecidea* sp.—4, 6, 10, 13, 15, 16, 18, 19, 23, 32; Ab, E, G, Hb, J, L, M; trunk and branches.

120. *Mycoblastus alpinus* (Fr.) Kernst.—3, 4, 6, 7, 8, 10; Ab, B, Fc, G, N; trunk and branches, often at the height of 100 feet.

121. *Mycoblastus sanguinarius* (L.) Norm.—6; N; upper trunk and branches.

122. *Bilimbia naegelii* (Hepp) Krmph.—13; L; upper trunk and branches.

123. *Bacidia albescens* Zwackh.—23; Fa; branches.

124. *Bacidia arceutina* (Ach.) Rehm.—14, 29, 33; Ha, Ia; trunk.

CLADONIACEAE

125. *Cladonia* sp.—4, 5, 6, 7, 8, 11, 13, 19, 32, 33, 35; B, E, Fa, Fc, Ha, Hb, Ib, K, L, M, N, O; trunk and branches, sometimes upper in both zones.

125a. *Cladonia chlorophaea* f. *simplex* (Hoffm.) Arn.—17; Ia; trunk.

125b. *Cladonia coniocraea* (Floerke) Spreng. f. *ceratodes* (Floerke) Dalla Torre & Sarnth.—8, 38; Hb, K; trunk and top of crown.

125c. *Cladonia coniocraea* (Floerke) Spreng. f. *truncata* (Floerke) Dalla Torre & Sarnth.—38; Hb; trunk.

125e. *Cladonia scabriuscula* f. *surrecta* (Floerke) Sandst.—19; J; trunk.

125f. *Cladonia squamosa* (Scop.) Hoffm.—8; C; trunk.

125g. *Cladonia transcendens* Wainio.—4, 7, 11; K, L; trunk and branches.

PERTUSARIACEAE

126. *Pertusaria amara* (Ach.) Nyl.—7, 11, 16, 19, 21, 23, 25; B, E, Fa, Ha, Hb, Ib, J; trunk and branches.

127. *Pertusaria ambigens* (Nyl.) Tuck.—7, 8, 19, 23, 32; B, E, Fa, Ib, K, L; trunk and branches, sometimes at height of 100 feet.

128. *Pertusaria multipuncta* (Turn.) Nyl.—4, 6, 7, 8, 10, 11, 13, 14, 19, 20, 23, 25, 29, 32, 37; B, C, E, Fa, G, Ha, Hb, Ib, J, K, L, M, N, O; trunk and branches, sometimes to height of 100 feet.

129. *Pertusaria pustulata* (Ach.) Duby.—17; Ia; trunk.

LECANORACEAE

130. *Lecanora hageni* Ach.—12, 14, 19; E, Ia, J; trunk.

131. *Lecanora pacifica* Tuck.—14, 15, 18, 19, 23, 29, 32, 37; Ab, E, Hb, Ia, J; trunk, occasionally upper, and branches.

132. *Lecanora subfusca* (L.) Ach.—10, 11, 19; Ab, G, Ha; trunk and branches, sometimes to height of 60 feet.

133. *Lecanora subfusca* var. *argentata* Ach.—10, 13, 19, 29, 31; B, G, Hb, J, K, L, O; trunk and branches, sometimes upper.

134. *Lecanora varia* (Ehrh.) Ach.—4, 7, 11, 13, 16, 18, 19, 20, 22, 23, 25, 33, 40, 43; B, C, E, Ha, Hb, Ib, J; trunk and branches, at times to height of 60 feet.

135. *Ochrolechia tartarea* (L.) Mass.—3, 4, 7, 8, 10, 11, 13, 16, 19, 20, 23, 25, 28, 29, 32; Aa, B, C, D, E, Fa, G, Hb, J, L, M, O; trunk and branches, often to height of 100 feet.

136. *Lecania cyrtella* (Ach.) Th. Fr.—2, 6, 11, 15, 16, 17, 18, 19, 22, 23, 25, 29, 43; Ab, G, Ha, Hb, Ia; trunk and branches.

PARMELIACEAE

137. *Parmelia enteromorpha* Ach.—2, 3, 4, 6, 7, 8, 11, 13, 15, 16, 19, 23, 25, 28, 29, 32, 37, 40; Aa, B, C, E, Fa, Fc, G, Ha, Hb, Ia, Ib, J, K, L, M, N, O; trunk and branches, often upper of both zones.

138. *Parmelia enteromorpha* f. *rugosa* (Merrill) Zahlbr.—3, 4, 7, 19; B, G, Ha, M; trunk and branches often to height of 100 feet.

139. *Parmelia lophyrea* Ach.—4, 8; Aa, B, C, D, K, M; trunk and branches and

upper branches to height of 100 feet, also twigs.

140. *Parmelia olivacea* (L.) Ach.—15, 16, 18, 19, 23, 29, 33; Ab, D, E, Ha, Hb, Ia; trunk and branches.

141. *Parmelia olivacea* var. *aspidota* Ach.—2, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19, 27, 28, 29, 33, 40; Ab, E, Ha, Hb, Ia, Ib, M; trunk and branches, occasionally to height of 60 feet.

142. *Parmelia perlata* (Huds.) Ach.—4, 8, 15, 19, 29; Ab, C, D; trunk and branches, occasionally upper.

143. *Parmelia perlata* var. *ciliata* (DC.) Duby.—4, 8, 19; Ab, C, J, L; trunk and branches, occasionally upper in both zones.

144. *Parmelia pertusa* (Schrank) Schaer.—4, 6, 13, 19, 29; B, D, Hb, J, L, N, O; trunk and branches, often upper in both zones.

145. *Parmelia physodes* (L.) Ach.—4, 7, 8, 11, 15, 16, 17, 18, 19, 21, 23, 25, 28, 39, 40; D, E, Fa, Ha, Hb, Ia, Ib, J; trunk and branches.

146. *Parmelia saxatilis* (L.) Ach.—1, 2, 7, 8, 10, 11, 13, 14, 16, 18, 19, 23, 28, 29, 37; Aa, Ab, B, C, D, E, Fa, G, Ha, Hb, Ia, Ib, J, L, O; trunk and branches, often from 60-100 feet in height, also small branches and twigs.

147. *Parmelia saxatilis* var. *Aizoni* Del.—7, 8, 15, 18, 19, 27; Aa, B, Ha, Hb, M; trunk and branches.

148. *Parmelia sulcata* Taylor.—1, 2, 3, 4, 7, 8, 11, 13, 15, 16, 17, 18, 19, 20, 23, 25, 27, 28, 29, 33, 40; Ab, B, C, D, E, Fa, G, Ha, Hb, Ia, Ib, J, K, L, M, O; trunk and branches, often to height of 60-100 feet.

149. *Parmelia vittata* (Ach.) Rohl.—3, 4, 6, 7, 8, 10, 19, 23, 25, 32, 37; B, E, Fa, Fc, G, L; trunk and branches, frequently the upper in both zones from 60-100 feet high.

150. *Cetraria glauca* (L.) Ach.—3, 4, 6, 7, 8, 10, 11, 13, 15, 16, 18, 19, 20, 21, 23, 25, 28, 29, 40; Aa, B, C, D, E, Fa, Fc, G, Ha, Hb, Ib, J, K, L, N, O; trunk and branches, frequently upper in both zones to 100 feet in height.

151. *Cetraria lacunosa* Ach.—4, 7, 8, 13, 16, 19, 20, 28, 29; B, C, E, Fa, J, K, L, O; trunk and branches, often the upper in both zones to 100 feet high.

152. *Cetraria merrillii* Dr.—1, 6; G, Hb; trunk and branchlets.

153. *Cetraria scutata* (Wulf.) Poetsch.—4, 6, 7, 8, 11, 18, 19, 21, 40; B, D, E, G, Hb, Ia, Ib, M; trunk and branches, occasionally to 100 feet in height.

154. *Cetraria tuckermani* Herre.—4, 6, 7, 8, 11, 16, 19, 21, 23, 25, 27, 28, 29, 40; Aa, B, C, D, E, Fa, Fc, Ha, Hb, Ia, Ib, J, L, M, N, O; trunk and branches, sometimes upper in both zones to 100 feet.

155. *Nephromopsis ciliaris* (Ach.) Hue.—4, 6, 7, 8, 10, 11, 15, 17, 19, 23, 25, 28, 29, 37, 40; B, C, E, Fa, Fc, G, Ha, Ia, Ib, J, O; trunk and branches sometimes upper parts of both zones to 60 feet high.

156. *Nephromopsis platyphylla* (Tuck.) Herre.—4, 6, 10; G; trunk and branches.

USNEACEAE

157. *Evernia prunastri* (L.) Ach.—1, 4, 7, 11, 16, 17, 18, 19, 21, 23, 25, 33; E, Ha, Hb, Ia, Ib; trunk and branches.

158. *Letharia vulpina* (L.) Hue.—7, 8, 11; Fc, G; trunk, upper branches.

159. *Alectoria jubata* (L.) Ach.—3, 4, 6, 7, 8, 10, 11, 16, 25, 40; Aa, B, Fb, Fc, G, Hb, Ib; trunk and branches, occasionaly the upper in each zone to height of 100 feet.

160. *Alectoria sarmentosa* Ach.—1, 3, 4, 6, 7, 8, 10, 11, 16, 19, 25, 28, 29, 39, 40; Aa, B, D, E, Fa, Fc, G, Hb, Ib, O; trunk and branches, both to 100 feet in height.

161. *Ramalina ceruchis* (Ach.) DeNot.—33; Ha; trunk.

162. *Ramalina digitata* Mey. et Flw.—12, 15, 19; Ab, D, E; trunk, branches, branchlets.

163. *Ramalina farinacea* (L.) Ach.—1, 4, 7, 8, 12, 14, 15, 17, 18, 19, 21, 23, 25, 27, 28, 29, 33, 38, 40; Ab, C, D, E, Ha, Hb, Ia, Ib, J, M; trunk and branches.

164. *Ramalina menziesii* Tuck.—16, 21, 22, 33; Ha, Hb; trunk and branches.

165. *Ramalina reticulata* (Noedh.) Krmphbr.—1, 2, 4, 11, 22, 33; Ab, Ha, Hb, M; principally branches.

166. *Ramalina roesleri* (Hochst.) Nyl.—19; D; branches.

167. *Usnea ceratina* Ach.—4, 7, 8, 11, 15, 16, 18, 19, 40; Aa, Ab, B, C, D, Hb, Ib, M; trunk and branches, occasionally to height of 100 feet.

168. *Usnea dasypoga* (Ach.) Rohl.—7, 8, 16, 19, 29, 32, 40; Aa, Ab, B, D, Fa, Ha, Hb, Ib, J, O; trunk and branches, on latter sometimes to height of 100 feet.

169. *Usnea hirta* (L.) Wigg.—1, 4, 7, 8, 11, 15, 16, 17, 18, 19, 21, 23, 25, 27, 28, 29, 39, 40; Ab, B, C, D, E, Fa, Ha, Hb, Ib, J, M, O; trunk and branches 100 feet high, also branchlets.

170. *Usnea longissima* Ach.—4, 19, 29; Ab, C, D, O; trunk and branches.

171. *Usnea plicata* (L.) Wigg.—4, 7, 8, 15, 18, 23; Ab, B, C, D, Fc, G, Ib, O; trunk and branches, occasionally the upper.

172. *Usnea trichoidea* Ach.—4, 7, 8, 15, 16; Aa, Ab, B, C, Fa, Ha, Hb; trunk and branches, on western hemlock to height of 100 feet in both zones.

CALOPLACACEAE

173. *Caloplaca cerina* (Ehrh.) Th. Fr.—4, 11, 15, 16, 17, 22, 23; Ab, C, E, Ha, Hb, Ia; trunk and branches, on the latter occasionally to 60 feet in height.

174. *Caloplaca pyracea* (Ach.) Th. Fr.—11, 12, 14, 16, 19, 20, 23, 24, 43; Ab, B, E, Ha, Hb, Ia; trunk and branches, sometimes upper in the latter zone.

TELOSCHISTACEAE

175. *Xanthoria candelaria* (L.) Kickx.—16, 17, 18, 19, 21, 33; Ha, Hb, Ia; trunk and branches.

175a. *Xanthoria candelaria* (L.) Kickx. var. *pygmaea*.—18; Hb; trunk.

176. *Xanthoria polycarpa* (Hoffm.) Oliv.—4, 14, 17, 18, 24, 33; C, Ha, Hb, Ia; trunk and branches.

BUELLIACEAE

177. *Buellia disciformis* (Fries) Mudd.—2, 18, 19, 20, 22, 23, 25; B, E, Hb, L; trunk and branches.

178. *Buellia oidalea* (Nyl.) Tuck.—19; O; trunk.

179. *Buellia penichra* (Tuck.) Hasse.—10; G; branches.

180. *Rinodina hallii* Tuck.—16, 23; E, Hb; trunk and branches.

181. *Rinodina sophodes* (Ach.) Mass.—4, 23; C, E; trunk and branches.

PHYSCIACEAE

182. *Physcia caesia* (Hoffm.) Hampe.—3, 6, 7, 8, 10, 28, 33; Fa, Fc, G, Ha; trunk and branches.

183. *Physcia hispida* (Schreb.) Frege.—4, 12, 14, 18, 19, 33; Ab, C, E, Ha, Hb, Ia; trunk and branches.

184. *Physcia tribacia* (Ach.) Nyl.—33; Ha; trunk.

LEPRARIACEAE

185. *Lepraria aeruginosa*.—1, 28, 33; Ha, Hb, Ib; trunk and branches.

186. *Lepraria candelaris*.—1, 2, 4, 7, 8, 11, 14, 16, 17, 19, 21, 25, 29, 33, 40, 42; Ab, Ha, Hb, Ia, Ib, J; trunk and branches.

187. *Lepraria* sp.—1, 2, 4, 7, 8, 11, 16, 18, 19, 22, 33, 42; Ab, B, Ha, Hb, Ia, Ib, M; trunk and branches, occasionally to 100 feet in height.

A Qualitative and Quantitative Study of the Plankton Algae in Southwestern Georgia[1,2]

George J. Schumacher

Harpur College, State University, N.Y., Endicott, New York

One of the principal aims of the Emory University and the United States Public Health Service Field Station at Newton, Georgia, has been to study the various ecological habitats of the Anopholene mosquitoes in Southwestern Georgia. It was apparent that a qualitative and a quantitative study of the plankton algae of the area should be made, for the algae are utilized as food and shelter by the larval stages. With the full cooperation of Major Melvin H. Goodwin, Jr., the station's director, a preliminary survey was conducted in the summer of 1949. An intensive study was begun in September, 1950, and continued through September, 1951. Thus observations were permitted throughout all seasons of a continuous twelve month period.

Methods and Materials

Fifteen collecting stations were selected for the quantitative phase of the survey. In habit, these stations varied from a cool clear spring to the black waters of a pond rich in organic matter; in size they ranged from a small temporary pig wallow to a permanent pond covering 640 acres.

Quantitative samples were taken monthly. Ten liters were taken at or near the surface of open water and strained through a #20 silk bolting cloth net. The net was inverted over a wide mouth pint jar and the residue was flushed into the jar by pouring pond water into the inverted net. In this manner, the net prevented the introduction of any extraneous material. Upon reaching the laboratory, the sample was reduced to 10 ml by elimination of the excess strained water. Thus each milliliter of concentrate represented one liter of pond water. After a thorough shaking, one milliliter was pipetted from the concentrate and placed in a Sedgewick-Rafter counting cell. This type of counting cell contains 1,000 cubic mm: its dimensions being 50 mm long, 20 mm wide and 1 mm deep. Before examining the cell, a Whipple Disc was inserted into an ocular and calibrated so when used with the low powered objective, the grid marking on the disc represented one square millimeter.

When the sample in the counting cell was viewed through the low power objective and the ocular containing the Whipple Disc, it was possible to count the number of plankton organisms in a cubic millimeter by enumerating all

[1] This paper was presented as part of a thesis to the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Ph.D.

[2] The author wishes to thank Dr. W. C. Muenscher for his constant counsel and to the U. S. Public Health Service and Emory University Field Station, Newton, Georgia, for furnishing the necessary funds and equipment for the survey.

those objects seen within the limits of grid markings on the ocular while focusing from the top to the bottom of the counting cell. This number, when multiplied by a thousand, would give the number of organisms in one milliliter which in reality represented one liter of pond water.

To supply a more accurate estimate, however, a single count was not relied upon. Instead, a diagonal path was followed across the counting cell and 10 cubic mm were counted at random spots along this path. The results of these 10 counts were totaled and averaged and the average was multiplied by 1,000 to supply the number of organisms per liter. When a colonial or a filamentous alga appeared, the individual cells were not considered, the entire colony or filament being counted as one.

Qualitative sampling was restricted only by the boundaries of the area and collections were made whenever the opportunity availed itself. For the most part, the samples were planktonic in nature, but occasional specimens of attached algae were taken.

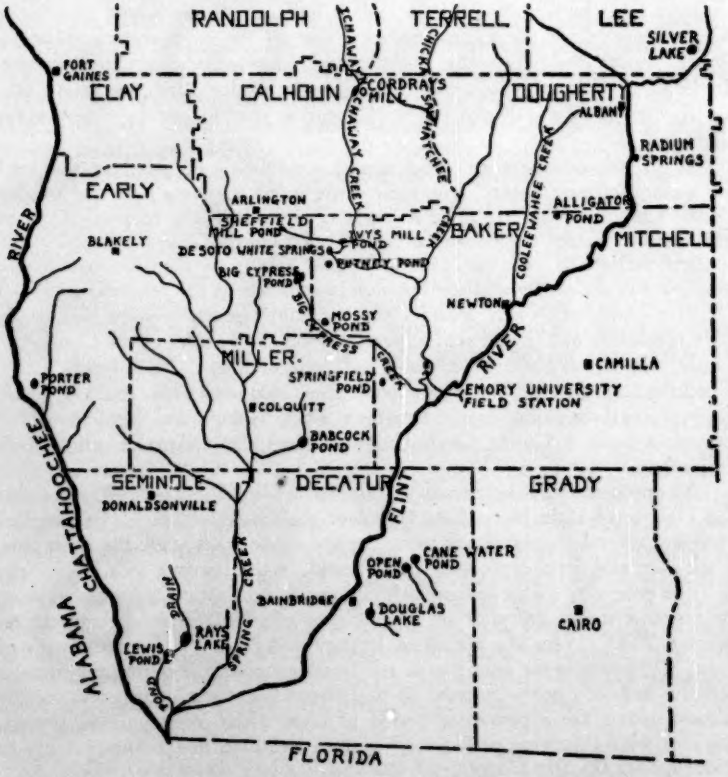


FIG. 1. MAP OF SOUTHWESTERN GEORGIA

Approximately one thousand bottles were collected and all samples were examined as soon as time permitted and in the fresh condition whenever possible. Semipermanent slides were made of all collections, the slides being mounted in glycerine jelly and ringed with balsam. The remaining material was preserved in 5-10% formalin. The bottles and slides have been deposited in the Botany Department of Cornell University.

DESCRIPTION OF THE AREA

The area is located in the southwestern corner of the state of Georgia. As shown by the map (fig. 1), it embraces all or part of the following eleven counties: Baker, Calhoun, Clay, Decatur, Dougherty, Early, Grady, Lee, Miller, Mitchell and Seminole. The region is limited by the following approximate coordinates: 31°45′N on the North, 84°03′W on the East, 30°40′N on the South and 85°07′W on the West.

Geologically, the area is divided into three parts. In the northwestern section, the Red Hills of the Paleocene and Eocene formations are best evidenced in the vicinity of Fort Gaines and extend southward in a finger like manner along the Chattahoochee River to the southwestern corner of Early County and along the Pochitla and Ichawaynochaway creek systems in Calhoun County. Soils in this section are of the dark red loamy sand or clay loam type and the rolling plateau is sharply cut by deep ravines and gullies.

The southeastern corner of the area is prominently bordered on the north by a diagonal escarpment. The escarpment enters the state near the junction of the Chattahoochee and Flint Rivers and runs across the southeastern third of Decatur County, the northwestern corner of Grady County and the southeastern portion of Mitchell County. This section is the Tifton Uplands which are underlain by a sandy limestone formation of the Miocene series.

The Dougherty Plain occupies the remaining central portion and covers over two-thirds of the area under investigation. It includes all of Dougherty, Baker, Miller and Seminole counties and parts of Lee, Clay, Calhoun, Early, Mitchell, Decatur and Grady counties. The Dougherty Plain is a low gently rolling plain possessing many limestone sinks, springs and streams. It is underlain by the Eocene Ocala limestone and the Oligocene Flint River formations.

As opposed to the hardwoods of the Red Hills, Thorne, 1949, notes that the Dougherty Plain has a flora typical of the Coastal Plain. The long-leaf pine and several species of oak mark the dry sandy areas while the slash pine, black gum and pond cypress are to be found on the low wet soils.

The proximity of the Gulf of Mexico and the Atlantic Ocean causes them to assert a direct influence on the climate of this region. Temperatures average 50-53° F for the month of January and 80-82° F for the month of July. Occasionally the temperature reaches above a 100° F during the summer months and dips below freezing in the winter, but these occurrences usually do not extend for a prolonged period of time. The long summers provide the area with a growing period varying from 242 days in Calhoun County to 250 days for Decatur County.

The amount of rainfall fluctuates considerably from year to year. The

average rainfall for the entire area is 51.1 inches, ranging from 49.4 inches in Calhoun County to 53.8 inches in Early County. The U.S.D.A. records, 1941 Yearbook, reveal about half the rainfall comes in amounts of one inch or more within twenty-four hours and the total amount of rainfall for a good wet year is about twice the amount of rain which falls during a dry year. To illustrate this point, the average rainfall for Baker County approximates 50.25 inches a year. During the twelve month period of the survey, a dry year was experienced and 36.47 inches of rain fell: a decrease of 37.4 percent from the normal. July and August are the months in which the heaviest precipitation occurs, averaging 6.1 inches and 5.7 inches respectively. However, the awaited rains did not materialize in 1951 and July had a rainfall of 3.47 inches while 3.03 inches fell in August.

DESCRIPTION OF QUANTITATIVE STATIONS

Babcock Pond.—Babcock Pond, located four miles east of Boykin in Miller County, measures approximately a quarter mile at its widest diameter and is oval in outline. The margins of the lake support a luxuriant plant growth. Nevertheless, a considerable amount of the deeper water remains free and open. In and about the shallows of the shoreline grow such plants as *Cephalanthus occidentalis* L. and *Pontederea cordata* L., while *Nuphar advena* Ait., *Nymphaea odorata* Ait., and *Brasenia schreberi* Gnel. represent the common aquatics with floating leaves and *Myriophyllum scabratum* Michx. and *Cabomba caroliniana* A. Gray represented the submersed species.

A stream, Big Drain, flows into the lake from the north and drains from the southwestern corner. When the site was visited for the first time in March, 1949, Big Drain was flowing normally and functioned as an inlet and outlet. The pond was revisited in October, 1950, at the commencement of the intensive survey. By this time the stream had become completely dry, and remained so for the next twelve months; the result being a gradual subsiding of the lake's level until the water's margin had receded twenty-five feet.

Porter Pond.—The pond is located in the southwestern corner of Early County, two and one-half miles from the Alabama border. The pond represents the most westerly location from which qualitative samples were taken. In size, plant life and general appearance, it resembles Babcock with the exception of its shallowness, being fifteen to twenty feet at its deepest spot.

The drought affected Porter to such an extent that on September 3, 1951, the water had been reduced to a puddle measuring two hundred feet in diameter and a mere eight inches in depth. To the owner, a farmer, this was an ideal situation because it offered him additional land for pasture. To assure the permanency of his newly acquired land, drainage ditches were dug to prevent the pond from refilling. It is doubtful whether this pond will ever regain the status it once held when the 1949 and early 1950 collections were made.

Rays Lake and *Lewis Pond.*—Rays and Lewis are located on Pond Drain, eight and one-half miles north of the Florida state line, in the southern portion

of Seminole County. Rays is three-quarters of a mile in length and is nearly twice the size of Lewis.

The feeding waters of Pond Drain are received by Rays and then by Lewis. As a result, it was the latter which suffered the most during the dry season. Lewis Pond was depleted to a quarter of its normal size, but Rays lost only forty feet along its shoreline. The aquatic vegetation of the ponds was quite similar; the shallow waters of their margins being heavily populated with species of *Myriophyllum, Nuphar,* and *Nymphaea.*

With the completion of the Jim Woodruff Dam at the junction of the Chattahoochee and Flint Rivers in Florida, a large portion of southern Seminole County will be inundated. The owners of Rays and Lewis have been informed that both bodies of water will be in the proposed flooded area. The completion of this project was scheduled for September, 1952, and it is assumed Rays Lake and Lewis Pond are no longer in existence.

Douglas Lake.—Douglas Lake is two and one-half miles southeast of Bainbridge in Decatur County. The lake is large and has a gradually sloping sandy bottom; its water remains cool and clear and a relatively large amount of its surface is entirely free of vegetation. The woody shores are subjected to alternate periods of inundation and dryness. One of the more noteworthy woody species found here is the water elm, *Planera aquatica* (Walt.) Gmel. Some of the common marginal and shallow water aquatics are *Echinodorus cordifolius* (L.) Griseb., *Ludwigia palustris* (L.) Ell. and *Polygonum hydropiperoides* Michx.

Open Pond.—Decatur County provided two more ponds for study, Open and Cane Water. Open Pond is situated nine miles northeast of Bainbridge. It measures almost one-half mile in length and has a sandy bottom sloping slightly toward the center with a large depression at the south portion. Because of the lack of rain, only four small puddles, each with a diameter of seventy-five yards, were evident in the winter of 1950-51. The water level rose in the spring and by April the pond had regained one-half its normal size and maintained this level throughout the rest of the survey.

The scarcity of aquatic plants was striking, and only an occasional flowering *Nelumbo lutea* (Willd.) Pers. or *Nymphaea odorata* Ait. was apparent.

Cane Water Pond.—One mile to the north of Open is Cane Water, another large, shallow bottomed body of water. In general aspect it resembles Babcock and its abundant vegetation is very similar. *Taxodium ascendens* Brongn. borders the pond, while *Ludwigia palustris* (L.) Ell. and *Juncus repens* Michx. are common shallow water inhabitants. *Brasenia schreberi* Gmel., *Cabomba caroliniana* A. Gray, *Nuphar orbiculata* Small and *Nymphaea odorata* Ait., all members of the Nymphaeaceae (water-lily family), occur in places throughout the deeper water.

Cane Water responded to the prolonged dry season in the same manner as Babcock: with a gradual recession of the shoreline to an extent of twenty to twenty-five feet.

Silver Lake.—Silver Lake represents the northeastern limit of the collecting area lying in Lee County, ten miles northeast of Albany. The lake is unique

in relationship to the others in this survey, being maintained as a private recreational area: the owners using it exclusively for boating, fishing and swimming. Consequently the lake received such treatment as stocking with fish, weeding of the margins, and fertilization to rid the deeper water of undesirable growth.

Unfortunately, Silver Lake suffered the same fate as many others during the drought, despite all efforts to the contrary. In an attempt to save the lake, its fish and its value, the owners used bulldozers to deepen the basin and water was pumped into it from a nearby spring. An account of the lake's gradual desiccation is recorded in the following sentences. By October, 1950, an estimated one thousand pounds of trout (bass) and two thousand pounds of sucker had been lost. A large portion of the lake bed had become so dry and overgrown that it was being used as pasture. In February, 1951, the lake was reduced to one small puddle about twenty-five feet in diameter. The situation fluctuated little during the spring and summer months, despite the endeavors mentioned above. Finally, the lake was completely dry in September, 1951.

Sheffield's Mill Pond and *Ivy's Mill Pond*.—Sheffield's Mill Pond is in the northeastern corner of Early County and Ivy's is in the northwestern corner of Baker County. In respect to Arlington, Sheffield is four miles to the southeast and Ivy's is ten miles to the southeast. The ponds are situated on Mill Creek which drains from Sheffield's into Ivy's.

Each pond has a dam, which maintains the water level and a diversion channel or pipe. Water is permitted to flow through the pipes whenever power is needed to turn the grinding wheels in the mill houses. Although the water level dropped appreciably in both ponds, it never reached a dangerous mark and a satisfactory height was maintained.

The outstanding characteristic of Sheffield's is the luxuriant growth of *Chara contraria* Braun which forms a dense green meadow over the entire bottom. One cannot row to any part of the large pond without encountering this lime encrusted stonewort. While *Chara* thrives on the bottom, the surface water is practically free of other aquatic plants.

In contrast, Ivy is heavily infested with vegetation, especially with members of the Nymphaeaceae growing to its water surface. In the summer months, when the water was low, the Water-lilies formed a blanket over the pond. With the shadowing effect of this carpet, submersed vegetation was kept at a minimum.

Big Cypress Pond.—The remaining five stations are located in the central portion of the studied area and are of particular interest as they are the focal points of many investigations conducted by the Emory University Field Station.

The largest pond is Big Cypress, covering six hundred and forty acres and lying in the eastern section of Early County at the head waters of Big Cypress Creek.

The pond is swamplike in appearance, being shallow and having a soft quaking mucky bottom, which often breaks open under the footsteps of an intruder. The marginal and shallow water areas support typical plants

as *Carex glaucescens* Ell., *Juncus marginatus* Rosth, *Juncus polycephalus* Michx., *Juncus scirpoides* Lam., *Typha latifolia* L. and *Wolfiella floridana* (J. D. Smith) C. H. Thompson. In the deeper water *Nymphaea odorata* Ait. and *Utricularia purpurea* Walt. are found.

A gradual falling of the water level was noted throughout the twelve month period. Upon drying, the pond exposed the presence of several deep holes. In August, 1951, a search of the six hundred and forty acres revealed the pond to be completely dry. All that remained in the deep sink holes was the dried mud, cracked wide and deep by long exposure to the sun.

Springfield Pond.—Three and a half miles southwest of the Field Station in Baker County is Springfield, located in an open wooded area. Essentially it is a very small and shallow pond covering about a half acre in area. However, after a heavy rainfall it often floods an extensive section of the low and level surrounding terrain.

Animals from a nearby farm, especially pigs, take delight in using the pond as a private wallow. Perhaps this and other uses by the animals have had some influence on the variety of plants growing luxuriantly there. The pond is bordered by a ring of *Acer rubrum* L. and *Nyssa sylvatica biflora* (Walt.) Sarg., while in the water abound such aquatics as *Callitriche heterophylla* Pursh., *Hydrocotyle umbellata* (L.) Ell., *Polygonum hydropiperoides* Michx., *Utricularia inflata* L. and the liverwort *Riccia fluitans* L.

The lowering of the water table, the infrequent rains and its small size contributed in making Springfield among the first of the ponds to become dry during the winter of 1950-51. Samples taken during the preliminary visits in the spring and summer of 1949 permitted the author to obtain enough information to present a qualitative picture of the algal flora. A complete quantitative view of Springfield Pond is impossible due to the lack of sufficient samples. This is also true for Putney and Mossy Pond, hence these three will not be presented graphically in the quantitative charts.

Putney Pond.—Putney is situated four miles north of Crestview in northwestern Baker County. It is a small pond lying in a shallow depression and is dependent upon rain and runoff for its water supply. In and about the water's edge are such wody plants as *Cephalanthus occidentalis* L., *Liquidamber stryaciflua* L., *Nyssa sylvatica* Marsh, *Quercus nigra* L., *Q. virginiana* Mill. and *Taxodium ascendens* Borngn. The common true aquatics are *Juncus repens* Michx., *Ludwigia palustris* (L.) Ell., *L. glandulosa* Walt., *Myriophyllum heterophyllum* Michx. and *Proserpinaca palustris* L.

During the survey period, Putney varied considerably in the amount of water which it held. In the summer of 1949, the water level was at its peak, covering several acres, and a boat was required to reach the center of the pond to obtain samples. When revisited in September, 1950, its size was a puddle eight feet in diameter and October of the same year it was dry. It remained this way until the first week in December when two inches of rain fell, forming a pool twenty-five feet in diameter. This level was maintained for the next two months and additional rains added to it until the pond held more water on March 27, 1951, than it had since the previous September. Unfortunately,

the months of June and July provided little rain and in August and September the pond was again dry.

Mossy Pond.—Approximately six and one-half miles west of Mimmsville, in Baker County, is Mossy Pond. The name is derived from the abundance of the graceful hanging tufts of *Tillandsia useneoides* L. (Spanish Moss) found in the surrounding trees. Mossy is quite like Putney; the water is rich, black and acid and the surrounding vegetation is also similar. A glance at a list of some plants common to this area will reveal the resemblance in habitat: *Cephalanthus occidentalis* L., *Hydrocotyle umbellata* L., *Juncus effusus* L., *J. marginatus* Rosth., *J. repens* Michx., *Myriophyllum heterophyllum* Michx., *Nyssa sylvatica* Marsh., *Pinus echinata* Mill., *Quercus nigra* L., *Q. virginana* Mill., *Riccia fluitans* L., *Ricciocarpus natans* (L.) Corda and *Taxodium ascendens* Brongn.

The fluctuating behavior of Putney was manifested in Mossy as well. In September, 1951, all that remained of the large pond was a small pool located in a shallow hole. The dryness of the next two months aggravated the situation and by November 21st the water was entirely gone. December brought a respite in the drought and a small amount of water reappeared. During March, April and May the entire surface of the water was blanketed with the liverwort, *Ricciocarpus natans* (L.) Corda. Nevertheless, the conditions grew worse and in June, 1951, the pond was without water; continuing in this state throughout the last visit in September.

De Soto White Springs.—The remaining station is in the general vicinity of the three preceding ponds, being two and one-half miles north of Crestview in western Baker County. Its appellation originates with the supposition that Hernando De Soto occupied this spot as a campsite on the night of March 17-18, 1540.

Several small subterranean springs are in the environs but the main spring was the locale for the collection station. Its flow is continuous, producing a cool, clear green colored water. A very small dam provides enough of a restriction to form a small pool for the water. With a source such as this, the drought had little effect on the water level, the maximum drop noted was one foot. The wooded area surrounding the spring came to the water's edge but the pool was practically free of aquatic plants.

All of the above stations, with the exception of Springfield Pond, are considered as permanent bodies of water. In the memories of the local inhabitants, drought conditions as were experienced during the survey have not occurred in many years and they are in agreement that Big Cypress, Mossy, Open, Porter and Putney have never been dry in the past thirty-five years. No apology is offered for the occurrence of a drought during a study such as this, but the author wishes the reader to be cognizant of the conditions under which the investigation was conducted.

DISCUSSION

In the following discourse, an attempt will be made to place the surveyed stations into groups, according to their qualitative and quantitative plankton flora. One can argue that such an arrangement would leave much to be

desired. However, certain natural algal associations do exist, especially in the Desmidiaceae (Prescott, 1948, and Brown, 1930). These associations are restricted to particular ecological conditions and can be recognized with comparative ease, it seems therefore justifiable to construct such a classification. If the endeavor to ally the ponds possessing similar algal characteristics is successful, a significant result will be achieved. It will become possible to predict, within limits, the potential qualitative and quantitative conditions of a lake or pond by reviewing the known facts of one or more lakes or ponds in the same group. This ability to prognosticate will in no way be absolute, nor will it give the inquisitor precise answers. It will present enough information to enable him to formulate reasonable assumptions. It is hoped this knowledge will not be restricted to phycological studies alone, but may be of use to those in the area who are interested in allied fields.

Three ponds comprise the first group—Babcock, Cane Water and Porter. In additions to their physical similarity, their resemblance is amplified by the type of aquatic plant life which inhabits the water surfaces. The three ponds have copius amounts of floating, broadleafed plants, i.e. *Brasenia, Nelumbo,* and *Nuphar.* The blanketing effect of these aquatics restricts the intensity of light available to the flora below. This inability of the light to penetrate to the lower levels is a vital factor in keeping the phytoplankton to a minimum. The meagerness of the phycological population is confirmed by the qualitative charts for the ponds under consideration (fig. 2). Only a single class of algae, Chrysophyceae, exhibited a significant peak during the year, and that was restricted to Babcock in the month of December. With this exception, the other classes showed a small and even population throughout the year. The Myxophyceae and Dinophyceae never reached above one thousand organisms per liter while the Chlorophyceae and Bacillarieae registered a slight but normal increase during the summer and spring months respectively.

In contrast to the limited quantitative numbers of algae, the variety of species within the individual ponds was quite noticeable, especially among the desmids. In Babcock, 17 desmid genera and 67 species were recorded. Cane Water had 16 desmid genera and 53 species while 16 genera and 58 species were determined for Porter. The similarity in generic and specific numbers is further strengthened by the fact that in each case, the most dominant genera were *Cosmarium, Micrasterias* and *Staurastrum.* Hence the first group is characterized by a plankton population 1) sparse in bulk, 2) rich in variety and 3) rather constant in seasonal distribution.

In one respect, the second group of ponds is similar to the previous one; both are desmid-optimum types of habitats with a wide variety of desmid species. Unlike the first group, these ponds had a phytoplankton community neither poor in number nor even in seasonal distribution. Big Cypress, Lewis and Rays have been placed here.

A review of the quantitative charts will show their populations to be large and subject to pulsations (fig. 3). In Rays Lake a bloom of the blue-green *Microcystis aeruginosa* Kütz. occurred in spring and again in the summer, reaching its greatest quantity in July when its teeming numbers made counting impossible. Although this phenomenon did not occur in either Big Cypress

or Lewis, it will be noted the number of Myxophyceae found in these two ponds average three to four times the blue-greens examined in those of group one.

Peridinium limbatum (Stokes) Lemm., a Dinophyceae, formed a "wasserblume" in Lewis in April. An increase was noted for the winter months and in March it rose tenfold, reaching 35,200 per liter in April. The next month brought a startling disappearance of the cells and only an occasional individual or two was encountered throughout the rest of the year.

The remaining classes of algae show trends which are approximated in all three ponds. It is evident these trends are not duplicated in exact numbers or in their month of occurrence, nevertheless one can not overlook the fact that the inclination does take place during the same season of the year. The

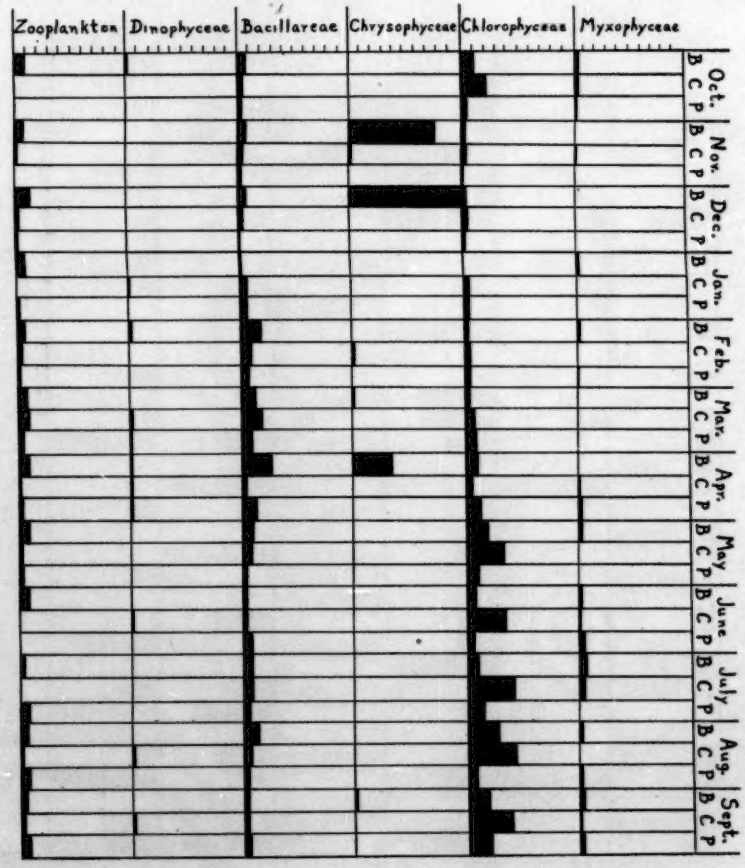


Fig. 2.—B = Babcock Pond; C = Cane Water Pond; P = Porter Pond.[3]

Chlorophyceae exhibited an increase in the fall, spring, and in one instance the late summer. A pulse of Chrysophyceae prevailed during the winter, while the Bacillarieae were more or less erratic but with a common growth in the winter months.

A luxuriant variety of desmids is indicated by the following figures. Big Cypress has yielded 16 genera and 66 species. In Lewis Pond, 15 genera and 41 species have been identified and in Rays Lake 13 genera and 45 species.

The dryness of the season has made positive placing of Mossy, Putney and Springfield Ponds impossible, however with the information that is available they should be classified in one of the above groups. In the author's opinion, their traits approximate those of the second group; i.e., a high desmid

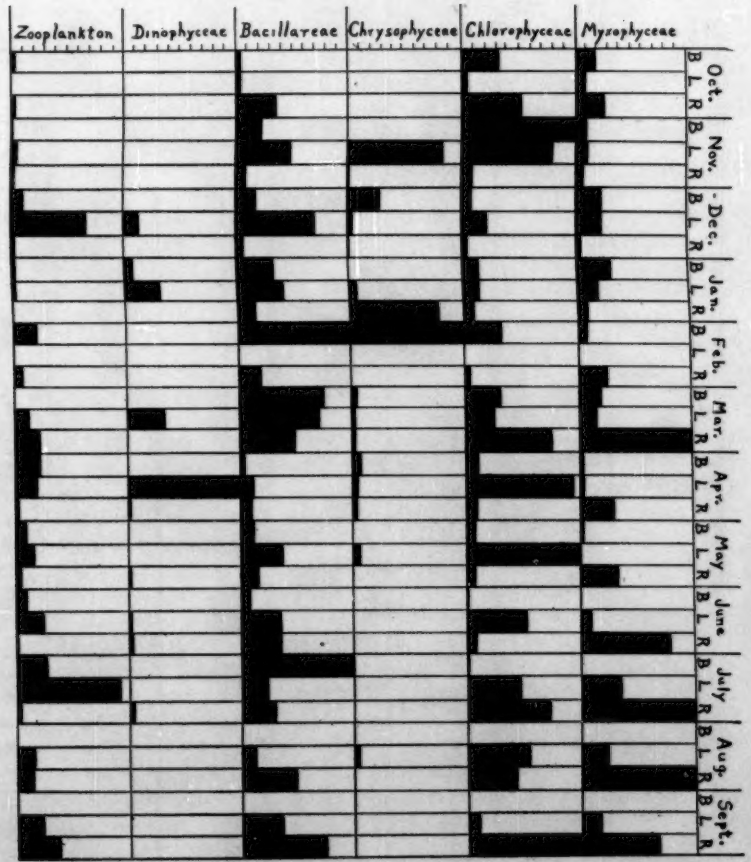


Fig. 3.—B = Big Cypress Pond; L = Lewis Pond; R = Rays Pond.[3]

variety, a pulsating population and a dense plankton community of one or more groups of algae.

The balance of the stations are joined together in a third group by the common intrinsic property of being desmid-poor. Moreover, their waters are clear and cool and their bottoms sandy, instead of the dark warm waters and mucky organic bottoms of the previous groups. The distinct qualities of the phytoplankton is not limited to the Desmidiaceae, for this assemblage is also characterized by a vast amount of diatoms and a relatively large number of blue-greens.

Sheffield's and Ivy's Mill ponds and Douglas are noteworthy exemplifications of this division. In these stations, the large volume of diatoms was not restricted to any particular season, instead they were present throughout

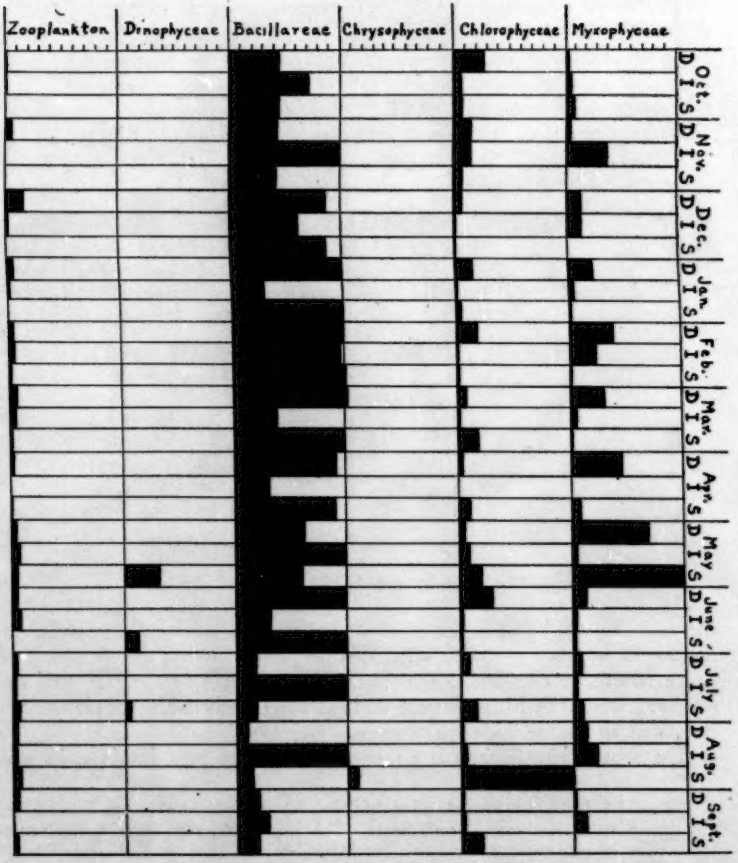


Fig. 4.—D = Douglas Pond; I = Ivy's Mill Pond; S = Sheffield's Mill Pond.[3]

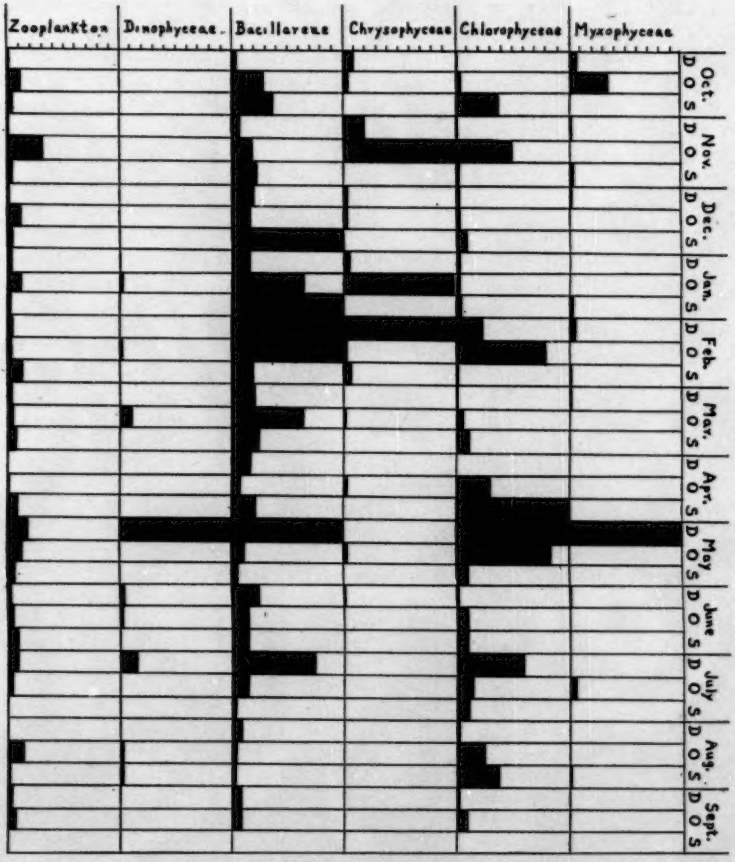


Fig. 5.—D = De Soto Springs; O = Open Pond; S = Silver Lake.[3]

the year (fig. 4). The largest number of diatoms being found in Sheffield's in the month of May (468,000 organisms per liter). With the exception of a single month in Sheffield's, the Chlorophyceae were limited to very small numbers, while the Myxophyceae enjoyed a relatively large population when compared to the desmid-rich locations.

De Soto White Springs is a member of this category, however, its small-

[3] Figs. 2-5 depict the populational trends of the various plankton groups for each pond, three ponds being combined in each figure. The fine markings on the abscissas represent the number of organisms in thousands per liter. The ordinates are divided into months, starting with October and ending with September. Each month is further subdivided into three sections, representing three different ponds.

ness of size and the constant subterranean source of water require it to be placed in an exclusive niche. In addition to the features listed above, De Soto also exhibited a bloom of Chrysophyceae in February and one of Dinophyceae in March. The unusually high numbers recorded for May are partially caused by the clogging of the dam with debris which restricted the normal flow of surface water over the dam.

Open Pond and Silver Lake cannot be classified with any degree of certainty due to the instability of their water levels. After considering all factors, however, the resemblance is greatest for those ponds in the desmid-poor group (fig. 5).

ANNOTATED LIST OF ALGAE FOUND IN SOUTHWESTERN GEORGIA

The system used in the following list is based largely upon that of G. M. Prescott (1951) in which the nature of the cell wall, the pigments found in the cell, the type of reserve food and the means of reproduction are taken into consideration.

Following each species name and its rate of occurrence is a series of numbers. The key to these is as follows: 1—Babcock; 2—Big Cypress; 3—Cane Water; 4—De Soto Springs; 5—Douglas; 6—Ivys; 7—Lewis; 8—Mossy; 9—Open; 10—Porter; 11—Putney; 12—Rays; 13—Sheffield; 14—Silver; 15—Springfield; 16—Other. The geographical abbreviations depict the known distribution of the species throughout the following states of the southeastern Coastal Plain: North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi and Louisiana. The word "New" denotes a species which has not been reported for this area.

Division CHLOROPHYTA

Class CHLOROPHYCEAE

Order VOLVOCALES

1. VOLVOCACEAE

1. *Gonium pectorale* Müll. Rare, entangled with floating green algae. 11. Ga., Miss., N.C.
2. *Pandorina morum* (Müll.) Bory. Common in strainings and squeezings. 1, 8, 11, 12, 14. Fla., Miss., N.C.
3. *Eudorina elegans* Ehr. Common, free floating. 1, 2, 3, 5, 7, 8, 9, 11, 12, 14, 15, 16. La., Miss., N.C.
4. *Pleodorina californica* Shaw. Rare, in squeezings and strainings. 1. New.
5. *Volvox aureus* Ehr. Common, in strainings. 1, 5, 8, 11. N.C.
6. *V. globator* L. Frequent. 14, 15, 16. La.
7. *V. mononae* G. M. Smith. Rare, found only in one pond. 15. N.C.

Order TETRASPORALES

2. PALMELLACEAE

8. *Sphaerocystis schroeteri* Chodat. Common, in squeezings and strainings. 1, 2, 3, 4, 5, 11, 14, 15, 16. Miss., N.C.
9. *Gloeocystis ampla* (Kütz.) Lag. Infrequent. 10, 12, 14. Fla.
10. *G. gigas* (Kütz.) Lag. Common, found in strainings and floating filamentous algae and debris. 1, 2, 3, 4, 6, 8, 11, 12, 13, 14, 16. Fla., Miss., N.C.

3. TETRASPORACEAE

11. *Tetraspora lubrica* (Roth) C. A. Agardh. Infrequent. 1, 2, 8. N.C.

4. COCCOMYXACEAE

12. *Elakatothrix viridis* (Snow) Printz. Infrequent, in squeezings. 7, 11, 16. New.

Order ULOTRICHALES

5. ULOTRICHACEAE

13. *Ulothrix subconstricta* G. S. West. Rare, some filaments found in strainings. 3. New.
14. *U. zonata* (Weber and Mohr) Kütz. Rare. 2, 8. New.
15. *Radiofilum conjunctivum* Schmidle. Frequent in squeezings. 1, 3, 8, 12, 16. New.

Order MICROSPORALES

6. MICROSPORACEAE

16. *Microspora* sp. Common, in strainings and squeezings. 2, 8, 11, 16.
17. *M. amoena* (Kütz.) Rab. Rare in strainings of one collection. 8. Fla., N.C.
18. *M. floccosa* (Vauch.) Thuret. Rare. 2. New.
19. *M. pachyderma* (Wille) Lag. Rare. 2. New.
20. *M. stagnorum* (Kütz.) Lag. Infrequent in squeezings. 2, 15. Fla., S.C.

Order CHAETOPHORALES

7. CHAETOPHORACEAE

21. *Stigeoclonium attenuatum* (Hazen) Collins. Rare, entangled on submerged roots. 12. New.
22. *Chaetophora elegans* (Roth) C. A. Agardh. Rare. 8. N.C.
23. *Draparnaldia glomerata* (Vauch.) C. A. Agardh. Rare, fragments found in strainings. 8. N.C.
24. *Aphanochaete repens* A. Braun. Rare, found on *Stigonema*. 16. Miss., N.C.

8. COLEOCHAETACEAE

25. *Coleochaete scutata* Bréb. Infrequent. 3, 4. Fla., Ga., N.C.
26. *Chaetosphaeridium globosum* (Nordst.) Klebahn. Rare on *Oedogonium* and misc. plants. 3. Fla.

Order CLADOPHORALES

9. CLADOPHORACEAE

27. *Cladophora uberrima* Lambert. Rare, on spillway of dam. 13. New.

Order OEDOGONIALES

10. OEDOGONIACEAE

28. *Bulbochaete* sp. Common, distribution so widespread that stations and collections will not be noted.
29. *B. tenuis* (Wittr.) Hirn. Rare, found entangled with other fil. algae, fruiting in May. 9. Miss.
30. *B. varians* var. *subsimplex* (Wittr.) Hirn. Rare, found fruiting in July on submerged dead stems and on *Stigonema ocellatum*. 16. Miss.
31. *Oedogonium* sp. Common, found in every quantitative station as well as all counties.
32. *O. crenulatocostatum* Wittr. Infrequent in squeezings, fruiting in May. 11. N.C.
33. *O. irregulare* Wittr. Common in fruiting condition in January. 2. Fla.

Order CHLOROCOCCALES

11. HYDRODICTYACEAE

34. *Pediastrum araneosum* var. *rugulosum* (G. S. West) G. M. Smith. Common, in a variety of habitats. 1, 5, 7, 12, 14, 16. Fla.
35. *P. biradiatum* Meyen. Infrequent. 11, 15. N.C.
36. *P. boryanum* (Turp.) Meneg. Frequent. 3, 5, 7, 12. Fla., Ga., N.C.
37. *P. boryanum* var. *longicorne* Raciborski. Rare. 4. N.C.

38. *P. duplex* Meyen. Frequent. 5, 8, 10. Fla., N.C.
39. *P. duplex* var. *coharens* Bohlin. Common, much more so than the type species. 5, 6, 7, 8, 11, 12, 14, 16. Miss. The abundance of specimens indicates that this variety may have a wider distribution than the literature indicates.
40. *P. tetras* (Ehr.) Ralfs. Common, in many situations. 1, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16. Fla., Ga., N.C.
41. *P. tetras* var. *tetraodon* (Corda) Rab. Rare in squeezings. 14. N.C.
42. *Sorastrum spinulosum* Näg. Infrequent. 1, 8, 12, 15. Fla. Although found in four ponds, it was infrequent in each collection.
43. *Coelastrum cambricum* Archer. Common, floating and entangled with other algae. 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 16. Fla., N.C.
44. *C. chodati* Ducellier. Rare, in strainings. 4. N.C. Originally described from France, this species has been reported from only a few scattered stations in this country. It was found only from this one station, De Soto, in the month of February. Its numbers were frequent in that single collection.
45. *C. microporum* Näg. Common. 2, 4, 7, 8, 10, 13, 14, 16. Fla.

12. OOCYSTACEAE

46. *Dictyosphaerium ehrenbergianum* Näg. Rare in squeezings. 11. New.
47. *D. pulchellum* Wood. Common. 2, 3, 5, 8, 10, 16. Fla., La., Miss., N.C.
48. *Planktosphaeria gelatinosa* G. M. Smith. Rare, in squeezings. 4. New.
49. *Oocystis borgei* Snow. Infrequent in squeezings. 10, 12, 16. Fla., N.C.
50. *O. crassa* Wittr. Infrequent, in strainings and squeezings. 3, 16. New.
51. *O. elliptica* W. West. Rare. 8. Fla., N.C.
52. *O. eremosphaeria* G. M. Smith. Rare. 2. New.
53. *O. lacustris* Chodat. Infrequent in squeezings. 7, 14. Fla.
54. *O. solitaria* Wittr. Infrequent. 1, 2, 10. New.
55. *O. solitaria* var. *major* Wittr. Rare. 7. New.
56. *O. submarina* Lag. Rare, in strainings. 9. New.
57. *Nephrocytium agardhianum* Näg. Infrequent in squeezings and strainings. 3, 5, 9. N.C.
58. *Dimorphococcus lunatus* A. Braun. Rare, in strainings. 3. Fla., La., N.C.
59. *Ankistrodesmus falcatus* (Corda) Ralfs. Common, in varied habitats. 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16. Fla., Ga., Miss., N.C., S.C. A wide distribution throughout the coastal plain.
60. *Selenastrum bibraianum* Reinsch. Rare, in strainings. 3. N.C.
61. *S. gracile* Reinsch. Common. 1, 5, 11, 14, 16. New.
62. *S. westii* G. M. Smith. Infrequent, in squeezings and strainings. 8, 12. N.C.
63. *Kirchneriella contorta* (Schmidle) Bohlin. Frequent. 4, 5, 7, 11. New.
64. *K. lunaris* (Kirch.) Moebius. Frequent. 1, 7, 11, 14. Fla., Ga., N.C.
65. *K. lunaris* var. *irregularis* G. M. Smith. Frequent. 5, 8, 15. New.
66. *K. obesa* (W. West) Schmidle. Rare, in strainings. 7. N.C.
67. *K. obesa* var. *aperta* (Teil.) Brunnthaler. Rare in squeezings. 16. N.C.
68. *K. obesa* var. *major* (Bernard) G. M. Smith. Rare. 8. N.C.
69. *Quadrigula* sp. Infrequent. 8, 16.
70. *Q. chodati* (Tan.-Ful.) G. M. Smith. Rare, in squeezings. 10. N.C.
71. *Q. lacustris* (Chodat) G. M. Smith. Frequent, in varied habitats. 8, 11, 14, 16. New.
72. *Tetraedron* sp. Infrequent, in squeezings and strainings. 2, 11.
73. *T. gracile* (Reinsch) Hansgrig. Rare. 1. N.C.
74. *T. limneticum* Borge. Rare, found in a tow. 5. N.C.
75. *T. planctonicum* G. M. Smith. Infrequent, in squeezings. 16. New.
76. *T. regulare* Kütz. Infrequent, in squeezings. 2, 8. Fla., La., N.C.
77. *T. regulare* var. *incus* Teil. Rare, in tow. 5. New.
78. *T. regulare* var. *torsum* (Turner) Brunnthaler. Rare, in strainings. 8. New.

13. SCENEDESMACEAE

79. *Scenedesmus abundans* (Kirch.) Chodat. Infrequent, in strainings and squeezings. 5, 11. N.C.

80. *S. acutiformis* Schroeder. Rare. 11. Fla.
81. *S. arcuatus* var. *platydisca* G. M. Smith. Common, in squeezings and strainings. 1, 8, 11, 12, 16. New.
82. *S. armatus* (Chodat) G. M. Smith. Frequent, in strainings and entangled with other algae. 4, 7, 14. N.C.
83. *S. armatus* var. *major* G. M. Smith. Rare, in squeezings. 14. New.
84. *S. bijuga* (Turp.) Lag. Common, in various types of collections. 1, 3, 5, 7, 8, 10, 11, 13, 16. Fla., Miss., N.C.
85. *S. brasiliensis* Bohlin. Common, in diversified habitats. 1, 2, 3, 5, 6, 8, 11, 12, 14, 16. Fla. A very common species whose range is probably greater in the coastal plain than is indicated by published reports.
86. *S. denticulatus* Lag. Infrequent, in squeezings. 8, 12. New.
87. *S. dimporphus* (Turp.) Kütz. Frequent in various collections. 4, 6, 8, 11, 16. Fla., N.C.
88. *S. hystrix* Lag. Infrequent. 1, 7, 8. New.
89. *S. longus* Meyen. Infrequent, in strainings and squeezings. 4, 10, 12. New.
90. *S. obliquus* (Turp.) Kütz. Rare. 11. Ga., Miss., N.C., S.C.
91. *S. opoliensis* Richter. Rare, in strainings. 8. N.C.
92. *S. quadricauda* (Turp.) Bréb. Common, free floating and entangled. 4, 5, 6, 11, 12, 13, 14, 15, 16. Fla., Miss., N.C.
93. *S. quadricauda* var. *parvus* G. M. Smith. Infrequent, in squeezings and among floating green filaments. 4, 8. New.
94. *Crucigenia* sp. Rare, in squeezings. 10.
95. *C. irregularis* Wille. Rare, in strainings. 7. New.
96. *C. quadrata* Morren. Rare, in strainings. 5. Miss.

Order SIPHONALES

14. VAUCHERIACEAE

97. *Vaucheria* sp. Common, on damp mud and entangled with other green filaments. 2, 8, 11, 15. Most abundant in January and February.

Order ZYGNEMATALES

15. ZYGNEMATACEAE

98. *Mougeotia* sp. Common. 1, 2, 3, 8, 10, 11, 12, 13.
99. *M. quadrangulata* Hassall. Rare, conjugating in January. 2. N.C. Found only in this one pond but material was adequate.
100. *Spirogyra* sp. Abundant throughout the year and in all counties. Exact stations and collections too numerous to list.
101. *Zygnema* sp. Situation similar to that of *Spirogyra*.

16. GONATOZYGACEAE

102. *Gonatozygon aculeatum* Hastings. Frequent, in squeezings. 1, 2, 10. Fla., Ga., N.C.
103. *G. pilosum* Wolle. Infrequent, in squeezings. 10, 11. Fla., N.C., S.C.

17. MESOTAENIACEAE

104. *Netrium digitus* (Ehr.) Itz. and Roth. Common, free floating and entangled with other algae. 1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 14, 16. Ala., Fla., Ga., Miss., N.C. This Desmid shows a wide range of tolerance in habitats.
105. *N. digitus* var. *constrictum* G. S. West. Rare, in squeezings. 16. New.
106. *Spirotaenia condensata* Bréb. Frequent. 2, 3, 10, 16. Fla., Ga., La., N.C., S.C.

18. DESMIDIACEAE

107. *Closterium* sp. Common. 1, 2, 3, 4, 7, 8, 10, 13, 15, 16.
108. *C. abruptum* W. West. Rare, in small puddles. 2. La., Miss., N.C.
109. *C. acerosum* (Schrank) Ehr. Infrequent, entangled with other algae. 13, 14. Fla., Ga., N.C., S.C.
110. *C. acerosum* var. *elongatum* Bréb. Infrequent, in strainings. 3, 8. Ala., Miss.
111. *C. angustatum* Kütz. Infrequent, in squeezings. 2, 15. Fla., Ga., Miss., N.C., S.C.
112. *C. cornu* Ehr. Rare, in squeezings. 16. Miss., N.C.

113. *C. cynthia* De Not. Frequent, in squeezings. 1, 2, 7, 12. Fla., Miss., N.C.
114. *C. didymotocum* Corda. Frequent, in various types of habitats. 2, 5, 7, 16. Fla., N.C.
115. *C. ehrenbergii* Meneg. Rare, in squeezings. 12. Fla., Ga.
116. *C. gracile* Bréb. Infrequent. 1, 7. Ala., Fla., N.C.
117. *C. gracile* var. *tenue* (Lemm.) W. West and G. S. West. Rare, in squeezings. 2. New.
118. *C. intermedium* Ralfs. Infrequent, in strainings. 2, 6. Fla., Miss., N.C.
119. *C. jenneri* Ralfs. Infrequent, in strainings. 1, 16. Ga., N.C.
120. *C. kützingii* Bréb. Common, in strainings and squeezings. 1, 2, 3, 6, 7, 8, 10, 11, 16. Fla., Ga., La., Miss., N.C.
121. *C. kützingii* var. *sigmoideum* Irénée-Marie. Rare, in strainings. 8. New.
122. *C. leibleinii* Kütz. Frequent. 2, 4, 7, 15. Fla., Ga., La., Miss., N.C., S.C.
123. *C. lineatum* Ehr. Rare. 2. Ala., Miss., N.C.
124. *C. lunula* forma *minor* W. West and G. S. West. Rare, in strainings. 16. New.
125. *C. macilentum* Bréb. Infrequent, in strainings. 2, 11. Miss.
126. *C. moniliferum* (Bory) Ehr. Rare, entangled with attached algae. 4. Ala., Fla., Ga., La., Miss., N.C.
127. *C. praelongum* Bréb. Rare, in strainings. 8. New.
128. *C. pritchardianum* Archer. Infrequent. 4, 12. Fla., N.C.
129. *C. pseudodianae* Roy. Rare, in strainings. 2. Fla.
130. *C. ralfsii* var. *immane* Cushman. Rare, in squeezings. 7. N.C.
131. *C. setaceum* Ehr. Common, in strainings and squeezings. 1, 2, 3, 7, 12. Fla., Ga., Miss., N.C., S.C.
132. *C. setaceum* forma *sigmoideum* Irénée-Marie. Rare, in strainings. 2. New. A new form described by Irénée-Marie, 1938; differing from the type only by its sigmoid shape.
133. *C. toxon* W. West. Frequent. 2, 10, 16. Fla., Miss., S.C.
134. *C. ulna* Focke. Rare, in strainings. 11. Ala., Fla., Miss., N.C., S.C.
135. *C. venus* Kütz. Infrequent, in squeezings. 2, 11. Fla., Miss., S.C.
136. *Penium* sp. Rare, entangled with other algae. 14.
137. *P. margaritaceum* (Ehr.) Bréb. Common, in squeezings. 1, 7, 8, 12, 15, 16. Fla., La., Miss., N.C.
138. *P. spirostriolatum* Barker. Rare, free floating. 2. Fla., Ga., N.C.
139. *Pleurotaenium* sp. Frequent, in many habitats. 3, 10, 12, 16.
140. *P. constrictum* (Bail.) Wood. Infrequent, in squeezings. 10, 16. Miss.
141. *P. ehrenbergii* (Bréb.) De Bary. Common, free floating and entangled. 1, 2, 7, 12, 16. Ala., Fla., Ga., Miss., N.C.
142. *P. minutum* (Ralfs) Delponte. Infrequent, associated with attached algae on aquatic stems. 10, 16. Fla., La.
143. *P. spinulosum* (Wolle) Brunel. Rare, in blue-green scum on mud. 16. Fla., La. Although being restricted to this one collection, the species was found in frequent numbers in the sample. This is but the sixth report for this alga since its original description by Wolle in 1881. The distribution throughout the world is as follows: N.J., Fla., La., 2 stations from Quebec and this report from Ga. A variety has been named from Madagascar.
144. *P. subcoronulatum* (Turner) W. West and G. S. West. Rare, in squeezings. 14. Fla.
145. *P. subcoronulatum* var. *detum* W. West and G. S. West. Common, free floating and associated with attached algae. 2, 3, 16. Ga., N.C.
146. *P. trabecula* (Ehr.) Näg. Frequent, in strainings and squeezings. 10, 13, 16. Fla., Ga., La., Miss., N.C., S.C.
147. *P. trabecula* var. *rectum* (Delponte) W. West and G. S. West. Frequent, in squeezing. 2, 7, 8, 12. Fla., Ga., N.C.
148. *P. trochiscum* var. *tuberculatum* G. M. Smith. Rare, with blue-green scum on mud. 16. Fla., Ga.
149. *P. truncatum* (Bréb.) Näg. Infrequent, with attached algae on aquatic stems. 7, 12. Fla., Miss.

150. *Triploceras gracile* Bailey. Frequent, in squeezings. 2, 3, 10, 16. Fla., Ga., Miss., N.C.
151. *T. verticillatum* Bailey. Frequent, in squeezings and strainings. 3, 10, 14, 16. Ala., Fla., Ga., Miss., N.C., S.C.
152. *T. verticillatum* forma *triradiatum* Taylor. Rare, in squeezings. 10. New.
153. *Tetmemorus brebissonii* (Meneg.) Ralfs. Infrequent. 2, 16. Fla., Ga., Miss., N.C., S.C.
154. *T. laevis* (Kütz.) Ralfs. Rare, in squeezings and strainings. 2. Fla., Ga., N.C.
155. *Euastrum* sp. Common, in squeezings and strainings. 1, 2, 7, 8, 10, 16.
156. *E. ansatum* Ralfs. Infrequent, squeezings and in roadside pig wallow. 7, 16. Fla., La., Miss., N.C., S.C.
157. *E. ansatum* Ralfs forma. Rare, in pig wallow. 16. New.
158. *E. bidentatum* Näg. Rare, in squeezings. 7. Fla., La., Miss., N.C.
159. *E. ciastronii* Raciborski. Infrequent, in squeezings. 7, 16. Fla., La., Miss.
160. *E. crassum* (Bréb.) Kütz. Infrequent, in squeezings. 10, 16. Fla., Ga., Miss.
161. *E. denticulatum* (Kirchner) Gay. Common. 1, 3, 12, 16. Fla., La., Miss.
162. *E. didelta* (Turp.) Ralfs. Rare, with algae on aquatic stems. 16. Fla., Ga., Miss., N.C., S.C.
163. *E. divaricatum* Lundell. Rare, on submerged stems. 16. La.
164. *E. elegans* var. *compactum* (Wolle) Krieger. Rare, in squeezings. 1. La.
165. *E. elegans* var. *novae semliae* Wille. Infrequent, in squeezings and with floating filamentous algae. 1, 13. Fla.
166. *E. evolution* (Nordst.) W. West and G. S. West. Frequent, in squeezings. 11, 15, 16. Fla., Miss., S.C.
167. *E. evolution* var. *glaziovii* (Borge) W. West and G. S. West. Infrequent. 10, 16. Fla., La., Miss.
168. *E. evolution* var. *integrius* W. West and G. S. West. Frequent, in squeezings. 1, 3, 16. Fla., Ga., La., Miss.
169. *E. intermedium* var. *longicolle* Borge. Rare, with blue-green scum on mud. 16. Fla., La., Miss.
170. *E. obesum* var. *crassum* Prescott and Scott. Infrequent, in squeezings. 7, 16. Miss.
171. *E. pinnatum* Ralfs. Infrequent, in squeezings and with attached algae. 7, 16. Ala., Fla., Ga., La., Miss., N.C.
172. *E. pinnatum* Ralfs forma. Rare, in pig wallow. 16. New.
173. *E. sibiricum* var. *exsectum* Gronblad. Rare, in squeezings. 2. La.
174. *E. sinuosum* Lenor. Rare, in squeezings. 16. Fla., Miss., N.C.
175. *E. trigibberum* W. West and G. S. West. Rare, on submerged stems. 14. Miss.
176. *E. verrucosum* Ehr. Rare, in tow. 5. Fla., Ga., N.C., S.C.
177. *E. wollei* Lag. Rare, in squeezings. 10. Ala., Fla.,
178. *Cosmarium amoenum* Bréb. Infrequent, in strainings and with attached algae on stems. 2. Fla., S.C.
179. *C. amoenum* var. *mediolaeva* Nordst. Rare, in strainings. 8. New,
180. *C. binum* Nordst. Rare. 16. La., Miss., N.C.
181. *C. blytii* Wille. Infrequent, in squeezings. 2, 16. Ala., Fla., Miss.
182. *C. circulare* Reinsch. Frequent, in strainings and entangled with attached algae. 1, 6, 12. Fla.
183. *C. commissurale* Bréb. Rare, in strainings. 16. Fla.
184. *C. commissurale* var. *crassum* Nordst. Infrequent, in strainings and with other algae. 1, 2. Fla., Ga., S.C.
185. *C. contractum* Kirchner. Rare, in squeezings. 12. Miss.
186. *C. cucurbita* Bréb. Infrequent, in squeezings and with floating algae. 2, 16. Ala., Miss.
187. *C. cyclicum* Lundell. Rare, in squeezings. 8. New.
188. *C. denticulatum* forma *borgei* Irénée-Marie. Frequent, in squeezings of aquatic stems. 4, 10, 15, 16. Miss.
189. *C. galeritum* Nordst. Infrequent, in strainings and squeezings. 2, 8. N.C.
190. *C. granatum* Bréb. Common, in squeezings and with attached algae. 4, 8, 12, 15. Fla.

191. *C. hammeri* var. *protuberans* W. West and G. S. West. Infrequent, entangled with floating filaments. 12, 16. Miss.
192. *C. holmiense* var. *integrum* Lundell. Rare, with *Oscillatoria* on dam. 6. New.
193. *C. impressulum* Elfv. Common, in variety of habitats. 8, 10, 11, 14, 16. Ga., Fla. In scraping the scum from the sides of a watering trough, a nearly pure culture of *Oscillatoria subtillissima* and *Cosmarium impressulum* was obtained. The cells of the desmid were in excellent condition and very abundant. This collection was made in October and subsequent visits revealed the same conditions.
194. *C. isthmium* W. West. Frequent, in strainings and squeezings. 1, 2, 16. Fla.
195. *C. margaritatum* (Lundell) Roy and Biss. Frequent, in strainings and squeezings. 1, 8, 16. Fla., Ga., Miss., S.C.
196. *C. margaritiferum* Meneg. Rare. 16. Fla., S.C.
197. *C. moniliforme* (Turp.) Ralfs. Rare, in strainings. 1. Fla.
198. *C. nitidulum* De Not. Infrequent. 10, 16. Fla.
199. *C. obtusatum* Schmidle. Infrequent, entangled with floating and attached algae. 10, 12. New.
200. *C. orbiculatum* Ralfs. Infrequent, in strainings. 6, 16. New.
201. *C. ornatum* Ralfs. Common, in strainings and squeezings. 2, 7, 8, 10, 12, 16. Ala., Fla.
202. *C. orthostichum* Lundell. Rare, in squeezings. 1. New.
203. *C. ovale* Ralfs. Rare, in tow. 12. Ga., La., N.C., S.C.
204. *C. pokornyanum* (Grun.) W. West and G. S. West. Rare, with blue-greens on dam. 6. New.
205. *C. portianum* var. *nephroideum* Wittr. Infrequent, with attached algae. 10, 16. Fla., Miss.
206. *C. pseudobroomei* Wolle. Rare, in squeezings. 16. Fla., N.C.
207. *C. pseudoconnatum* Nordst. Common, in strainings and with attached algae. 1, 2, 3, 4, 5, 12, 15, 16. Fla., Ga., Miss., N.C. Used by Frohne, 1939, as an indicator of the Desmid-optimum type of habitat.
208. *C. pseudopyramidatum* Lundell. Rare, with attached algae on roots and stems. 12. Ala., Fla.
209. *C. pseudopyramidatum* forma *tuberculata* Prescott and Scott. Rare, in strainings. 8. Miss.
210. *C. punctulatum* var. *subpunctulatum* (Nordst.) Börg. Common, in various habitats. 1, 2, 3, 11, 13. Ala., Fla.
211. *C. pyramidatum* Bréb. Frequent, entangled with attached algae. 1, 3, 16. Fla., Ga., Miss., N.C.
212. *C. quadrum* Lundell. Rare, in strainings. 8. New.
213. *C. quinarium* Lundell. Common, in squeezings. 1, 2, 3, 10, 16. Ga., Miss.
214. *C. regnellii* Wille. Common, with algae on submerged stems. 4, 8, 11, 12, 14, 15. Fla., Miss.
215. *C. retusiforme* var. *alpinum* Schmidt. Rare, in squeezings. 2. Miss.
216. *C. subtumidum* Nordst. Rare, free floating and entangled with attached algae. 2. Fla., Miss.
217. *C. subprotumidum* Nordst. Infrequent, in squeezings and with floating fil. algae. 11, 14. New.
218. *C. taxichondrum* Lundell. Rare. 10. New.
219. *C. taxichondrum* Lundell forma. Rare, in squeezings. 1. New.
220. *C. triplicatum* Wolle. Rare, in squeezings. 11. Fla.
221. *Arthrodesmus* sp. Rare, in strainings. 3.
222. *A. bulnheimii* var. *subincus* W. West and G. S. West. Rare, in squeezings. 3. Miss.
223. *A. convergens* Ehr. Rare, in squeezings. 1. Fla., Ga., N.C., S.C.
224. *A. incus* var. *extensus* Anders. Infrequent. 1, 10. Ga., Miss., N.C.
225. *A. triangularis* var. *rotundus* (Raciborski) G. M. Smith. Rare, in tow. 5. New.
226. *Xanthidium* sp. Common, in various habitats. 3, 6, 10, 12, 14, 15, 16.
227. *X. antilopaeum* (Bréb.) Kütz. Common, in strainings and squeezings. 1, 10, 12, 14, 16. Fla., Ga., Miss., N.C., S.C.
228. *X. antilopaeum* var. *minneapoliense* Wolle. Frequent, in squeezings and with attached algae on roots. 1, 2, 7, 12. Fla., Ga., N.C., S.C.

229. *X. antilopaeum* var. *polymazum* Nordst. Infrequent, in strainings and squeezings. 1, 3. Fla., Ga., N.C., S.C.
230. *X. armatum* (Bréb.) Rab. Rare, in tow. 5. Fla., Miss., S.C.
231. *X. armatum* var. *fissum* Nordst. Rare, in squeezings. 16. New.
232. *X. armatum* var. *mediolaeve* G. M. Smith. Common, free floating and entangled with attached algae. 1, 2, 4, 6, 10, 11, 16. Fla.
233. *X. cristatum* Bréb. Rare, in squeezings. 15. Fla., Ga., Miss., S.C.
234. *X. cristatum* var. *uncinatum* Bréb. Frequent, in strainings and squeezings. 1, 2, 3, 10. Ga., Miss., N.C.
235. *X. pseudobengalicum* Gronblad. Rare, in squeezings. 10. Fla.
236. *X. subhastiferum* W. West and G. S. West. Rare, in tow. 5. Fla.
237. *Staurastrum* sp. Common, in strainings and squeezings. 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 14, 15, 16.
238. *S. anatinum* Cocke and Wills. Infrequent, in squeezings. 7, 10. New.
239. *S. anatinum* var. *denticulatum* (Cocke and Wills) G. M. Smith. Rare, in strainings. 16. New.
240. *S. anatinum* var. *truncatrum* W. West. Rare, in strainings. 3. New.
241. *S. anchora* W. West and G. S. West. Rare, in strainings. 3. New.
242. *S. ankyroides* var. *pentacladum* Wolle. Rare, in strainings. 16. New.
243. *S. apiculatum* Bréb. Rare, with floating green filaments. 2. New.
244. *S. arctiscon* (Ehr.) Lundell. Common, in strainings and squeezings. 1, 3, 7, 11, 16. Fla., Miss., N.C.
245. *S. arctiscon* var. *truncatum* Irénée-Marie. Infrequent, in squeezings. 3, 16. New.
246. *S. brasiliense* var. *lundellii* W. West and G. S. West. Infrequent, in strainings and squeezings. 10, 16. Ala., Fla., Miss., S.C.
247. *S. breviaculeatum* G. M. Smith. Rare, in with floating green filaments. 2. New.
248. *S. brevispinum* Bréb. Rare, entangled with algae about submerged plants. 12. N.C.
249. *S. cuspidatum* Bréb. Infrequent, entangled with filamentous algae. 13, 16. Fla.
250. *S. dejectum* Bréb. Rare, in squeezings. 12. Ala., Fla., Ga., Miss., S.C.
251. *S. dickiei* Ralfs. Rare, in squeezings and strainings. 1. La.
252. *S. dickiei* var. *maximum* W. West and G. S. West. Infrequent, in strainings and squeezings. 1, 5. Fla.
253. *S. dilatatum* Ehr. Rare, entangled with attached algae. 13. Fla., Miss., N.C.
254. *S. furcigerum* Bréb. Rare, in squeezings. 14. Fla., Ga., S.C.
255. *S. furcigerum* var. *armigerum* (Bréb.) Nordst. Rare, in squeezings and with floating algae. 14. New.
256. *S. gracile* Ralfs. Rare, with attached algae. 2. Fla., Ga., Miss., S.C.
257. *S. grallatorium* var. *forcipigerum* Lag. Rare, in squeezings. 10. Fla.
258. *S. grande* var. *parvum* W. West. Rare, in squeezings. 1. Fla.
259. *S. gyrans* Johnson. Rare, in squeezings. 1. Fla., Miss.
260. *S. hystrix* Ralfs. Rare in floating debris. 13. Fla.
261. *S. johnsonii* var. *depauperatum* G. M. Smith. Rare, in squeezings. 16. New.
262. *S. leptocladum* Nordst. Frequent, in squeezings and free floating. 1, 5, 12. Fla., Miss.
263. *S. leptocladum* var. *insigne* W. West and G. S. West. Rare, in squeezings. 1. New.
264. *S. longispinum* (Bailey) Archer. Frequent, in strainings and entangled with attached algae. 3, 6, 12, 16. Fla.
265. *S. megacanthum* Lundell. Rare, in strainings. 3. N.C.
266. *S. minnesotense* Wolle. Infrequent, in squeezings. 10, 16. Fla
267. *S. muticum* Bréb. Rare, with attached algae on aquatics. 3. Fla., N.C.
268. *S. ophiura* Lundell. Infrequent, free floating. 2, 10. Fla., Miss.
269. *S. orbiculare* Ralfs. Infrequent, free floating and in squeezings. 9, 12. Fla., N.C.
270. *S. pentacerum* (Wolle) G. M. Smith. Rare, in strainings. 9. Miss.
271. *S. pinnatum* var. *reductum* Krieger. Infrequent, in squeezings. 1, 7. New.
272. *S. setigerum* Cleve. Infrequent, in with floating green filaments. 2, 13. Fla., Ga., N.C.
273. *S. setigerum* var. *brevispinum* G. M. Smith. Infrequent, in tow and squeezings. 1, 5. New.
274. *S. tetracerum* Ralfs. Rare, in squeezings. 12. Fla., Ga., Miss.

275. *S. tohopekaligense* var. *brevispinum* G. M. Smith. Infrequent, in strainings. 1, 11. N.C.
276. *S. trifidum* var. *inflexum* W. West and G. S. West. Infrequent, in squeezings and strainings. 2, 3. Fla.
277. *S. urinator* G. M. Smith. Rare, in squeezings. 3. New.
278. *Micrasterias apiculata* (Ehr.) Meneg. Common, free floating and with attached algae on stems. 2, 3, 4, 6, 11, 16. Fla., Ga., La.
279. *M. apiculata* var. *fimbriata* (Ralfs) Nordst. Rare, in tow. 12. Ala., Fla., Ga.
280. *M. apiculata* var. *fimbriata* forma *spinosa* (Biss.) W. West and G. S. West. Rare, in strainings. 2. Fla., Ga., N.C.
281. *M. arcuata* Bailey. Rare, with floating green filaments. 10. Ala., Fla.
282. *M. denticulata* Bréb. Rare, in squeezings. 1. Ala., Fla., Ga., Miss., N.C., S.C.
283. *M. denticulata* Bréb. forma. Infrequent, floating in pond and pig wallow. 7, 16. New.
284. *M. depauperata* var. *kitchelii* (Wolle) W. West and G. S. West. Frequent, in squeezings. 2, 10, 16. Fla., La., N.C.
285. *M. floridensis* Salisbury. Common, in strainings and squeezings. 1, 2, 6, 10, 16. Fla., N.C.
286. *M. floridensis* var. *spinosa* Prescott and Scott. Frequent, in strainings and tow. 3, 5, 11. Fla., Miss.
287. *M. foliacea* Bailey. Common, in a variety of habitats. 2, 3, 10, 11, 12, 15, 16. Ala., Fla., Ga., La., N.C.
288. *M. laticeps* Nordst. Common, in strainings and squeezings. 1, 3, 5, 7, 8, 11, 12, 16. Fla., Ga., Miss., N.C.
289. *M. mahabuleshwarensis* Hobs. Frequent, in squeezings and strainings. 1, 3, 5, 15. Fla., Ga., La., Miss.
290. *M. muricata* (Bailey) Ralfs. Frequent, free floating and entangled with other algae. 3, 10, 14, 16. Fla., Ga., La., Miss., N.C.
291. *M. pinnatifida* (Kütz.) Ralfs. Common, free floating and with attached algae. 1, 2, 3, 7, 8, 10, 11, 14, 16. Fla., Ga., La., Miss., N.C.
292. *M. radiata* Hassall. Common, in varied situations. 1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 14. Fla., Ga., La., Miss., N.C. The most widespread *Micrasterias* throughout this area.
293. *M. radiata* var. *gracillimum* G. M. Smith. Rare, in squeezings. 8. Fla., La., Miss.
294. *M. radiata* var. *simplex* (Wolle) G. M. Smith. Infrequent, in squeezings and strainings. 1, 3. Ga.
295. *M. radiosa* Ralfs. Frequent, with filamentous algae and in strainings. 2, 3, 5, 8. Ala., Fla., La., Miss., N.C.
296. *M. radiosa* var. *ornata* Nordst. Infrequent, in squeezings and strainings. 1, 16. Fla., Miss., S.C.
297. *M. radiosa* var. *ornata* forma *elegantior* G. S. West. Frequent, in squeezings and strainings. 1, 2, 3, 8. Ga., N.C.
298. *M. ranoides* Salisbury. Infrequent, in strainings. 10, 16. Fla.
299. *M. torreyi* Bailey. Frequent, in strainings and squeezings. 3, 7, 11, 16. Fla., N.C.
300. *M. truncata* (Corda) Bréb. Common, free floating and entangled with attached algae. 1, 2, 3, 4, 16. Ala., Fla., Ga., Miss., N.C.
301. *Onychonema filiforme* (Ehr.) Roy and Biss. Frequent, in squeezings and tow. 1, 12, 16. Fla., Ga., Miss.
302. *O. laeva* Nordst. Frequent, strainings and squeezings. 1, 3, 7, 14. Fla., Ga.
303. *O. laeva* var. *latum* W. West and G. S. West. Common in squeezings, strainings and tows. 1, 5, 7, 8, 10, 11, 12. Fla., Ga., Miss., N.C.
304. *Sphaerozosma excavata* Ralfs. Frequent, in strainings and squeezings. 3, 7, 11. Fla., Ga., Miss., S.C.
305. *S. granulatum* Roy and Biss. Infrequent. in squeezings. 1, 16. Miss., N.C.
306. *Spondylosium moniliforme* Lundell. Frequent, in strainings and squeezings. 1, 11. 12. New.
307. *S. planum* (Wolle) W. West and G. S. West. Common, in strainings and squeezings. 1, 3, 7, 8, 12, 16. Ala., Fla., Ga., N.C.

308. *S. pulchrum* (Bailey) Archer. Common, free floating and with attached algae on stems. 3, 5, 11, 14, 16. Fla., N.C.
309 *Hyalotheca dissiliens* (Smith) Bréb. Common, in strainings and squeezings. 2, 3, 9, 11, 12, 15. Fla., Ga., La., Miss., N.C., S.C.
310. *H. mucosa* (Dillw.) Ehr. Common, in many and various habitats. 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16. Fla., Ga., Miss., N.C., S.C. The most common and widespread desmid in this area.
311. *H. undulata* Nordst. Infrequent, entangled with floating and attached algae. 12, 16. Fla.
312. *Phymatodocis nordstedtianum* Wolle. Infrequent, in squeezings. 7, 16. Fla., N.C., S.C.
313. *Desmidium aptogonium* Bréb. Common, free floating and entangled with attached algae. 1, 2, 3, 7, 10, 11, 14, 16. Fla., Ga., Miss., N.C., S.C.
314. *D. baileyi* (Ralfs) Nordst. Common, in strainings and squeezings. 1, 9, 10, 11, 12, 16. Ala., Fla., Ga., La., N.C.
315. *D. grevillii* (Kütz.) De Bary. Common, in strainings and squeezings of attached algae. 2, 3, 5, 7, 8, 11, 12, 13, 16. Fla., Ga., Miss., N.C., S.C.
316. *D. swatrzii* C. A. Agardh. Common, in strainings and squeezings. 1, 3, 7, 12, 14, 15, 16. Ala., Fla., Ga., La., Miss., N.C., S.C.
317. *D. swartzii* var. *amblyodon* (Itz.) Rab. Rare, in strainings. 11. New.
318. *Gymnozyga moniliformis* Ehr. Common, in variety of habitats. 1, 2, 3, 5, 6, 7, 8, 10, 14, 15, 16. Ala., Fla., Ga., Miss., N.C.
319. *G. moniliformis* var. *gracilescens* Nordst. Frequent, in squeezings. 1, 2, 7. Ala., Fla., Miss., N.C.

Class CHAROPHYCEAE

Order CHARALES

19. CHARACEAE

320. *Chara contraria* A. Braun. Rare. 13. New. Rare in as much as it is restricted to this one pond, however, it forms a dense growth over the entire bottom of the pond.

Division CHRYSOPHYTA

Class CHRYSOPHYCEAE

Order CHRYSOMONADALES

20. SYNURACEAE

321. *Synura uvella* Ehr. Frequent, in strainings. 1, 11, 15. Ga., N.C., S.C.

21. OCHROMONADACEAE

322. *Dinobryon* sp. Common, in strainings and squeezings. 1, 2, 4, 9, 14.
323. *D. bavaricum* Imhof. Infrequent, in strainings and squeezings. 5, 16. N.C.
324. *D. divergens* Imhof. Infrequent, in strainings and entangled with attached algae. 2, 4, 10. N.C. This species has been considered as an alga frequenting habitats which are inland and upland rather than on the coastal plain. In De Soto it reached tremendous numbers during the winter months.
325. *D. sertularia* Ehr. Common, in strainings and squeezings. 1, 5, 6, 13, 16. Fla., Ga., N.C., S.C.

Order RHIZOCHRYSIDALES

22. RHIZOCHRYSIDACEAE

326. *Chrysopyxis bipes* Stein. Rare, on filaments of *Mougeotia*. 3. New. The only other published record in the U.S. for this alga is by J. B. Lackey (1939) for Ohio. Through correspondence, G. M. Smith notes Thompson has written him that he has found it in Maryland. Therefore, this is but the third station for this unique species in the United States.
327. *Lagynion ampullaceum* (Stokes) Pascher. Rare, on *Oedogonium*. 3. New.

328. *L. macrotrachelum* (Stokes) Pascher. Infrequent, on *Hapalosiphon*. 2, 10. N.C.

Division PYRROHOPHYTA

Class DINOPHYCEAE

Order PERIDINIALES

23. GLENODINIACEAE

329. *Glenodinium* sp. Common, in strainings and tows. 1, 4, 5, 12, 14, 15, 16. N.C.

24. PERIDINIACEAE

330. *Peridinium* sp. Frequent, in strainings and entangled with fil. green algae. 1, 8, 15.
331. *P. limbatum* (Stokes) Lemm. Rare, in strainings. 7. New.

25. CERATIACEAE

332. *Ceratium carolinianum* (Bailey) Jorgensen. Frequent, in strainings and squeezings. 2, 3, 16. Fla., Ga., N.C., S.C.
333. *C. hirundinella* (Müll.) Dujardin. Infrequent, in tow. 5, 7. N.C.

Division CYANOPHYTA

Class MYXOPHYCEAE

Order CHROOCOCCALES

26. CHROOCOCCACEAE

334. *Chroococcus dispersus* (Keissl.) Lemm. Rare, in strainings and squeezings. 3. N.C.
335. *C. dispersus* var. *minor* G. M. Smith. Rare, in strainings. 1. New.
336. *C. limneticus* Lemm. Common, in various habitats. 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 14, 15, 16. N.C.
337. *C. limneticus* var. *elegans* G. M. Smith. Rare, in strainings. 1. New.
338. *C. limneticus* var. *subsalsus* Lemm. Common, in squeezings and strainings. 1, 5, 7, 8, 10, 12, 14, 15, 16. Miss.
339. *C. minutus* (Kütz.) Näg. Common, free floating and with attached algae. 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 14, 16. Miss., N.C.
340. *C. turgidus* (Kütz.) Näg. Rare, in squeezings. 7. Fla., N.C., S.C.
341. *Aphanocapsa elachista* W. West and G. S. West. Common, in strainings and squeezings. 1, 2, 10, 11, 16. N.C.
342. *A. grevillei* (Hassall) Rab. Common, in strainings and squeezings. 1, 2, 3, 8, 9, 12, 14, 16. Fla., N.C., S.C.
343. *A. pulchra* (Kütz.) Rab. Infrequent, in strainings. 7, 14. Fla., N.C.
344. *A. rivularis* (Carm.) Rab. Infrequent, in strainings. 8, 16. New.
345. *Microcystis aeruginosa* Kütz. Infrequent, in strainings and with attached algae. 7, 12. La., Miss., N.C. This blue-green formed a heavy "Bloom" in Rays Lake during the summer months.
346. *M. flos-aquae* (Wittr.) Kirchner. Infrequent, in strainings and squeezings. 1, 11. New. Prescott (1951) places this species in synonymy with *M. aeruginosa* on the basis that *M. flos-aquae* is nothing more than a globose, non-clathrate condition of *M. aeruginosa*.
347. *M. incerta* Lemm. Rare, in squeezings. 14. New.
348. *M. pulvera* (Wood) Migula. Common, in strainings and squeezings. 1, 2, 8, 11, 16. Fla., S.C. Prescott (l.c.) assigned this species to *M. incerta*.
349. *Merismopedia elegans* A. Braun. Frequent, free floating and with attached algae. 2, 7, 8. Fla., Miss.
350. *M. glauca* (Ehr.) Näg. Common, in various situations. 1, 2, 3, 4, 7, 9, 10, 11, 12, 15, 16. Fla., N. C.
351. *M. punctata* Meyen. Common, in squeezings. 3, 8, 10, 12, 16. Fla., Miss., N. C.
352. *M. tenuissima* Lemm. Frequent, in strainings and squeezings. 7, 8, 16. N. C.
353. *Gloeothece rupestris* (Lyngb.) Bornet. Infrequent, in strainings and tow. 5. 8. N. C.

354. *Aphanotheca nidulans* Richter. Frequent, in strainings and squeezings. 2, 3, 9. New.
355. *A. saxicola* Näg. Rare, in squeezings. 10. New.
356. *A. stagnina* (Spreng.) A. Braun. Frequent, in strainings and squeezings. 9, 11, 16. New.
357. *Coelosphaerium dubium* Grunow. Infrequent, in squeezings and tow. 1, 5. New.
358. *C. kutzingianum* Näg. Frequent, in strainings. 5, 11, 13. New.
359. *C. naegelianum* Unger. Common, in squeezings and free floating. 1, 3, 5, 7, 9, 11, 12. Fla., N. C.
360. *Gomphosphaeria lacustris* Chodat. Rare, in strainings and tow. 5. N. C.

Order HORMOGONALES

27. OSCILLATORIACEAE

361. *Spirulina princeps* (W. West and G. S. West) G. S. West. Infrequent, free floating and with attached algae on stems. 10, 11. Fla., N. C.
362. *Oscillatoria* sp. Common, attached to submerged roots, dam boards, soil, and as floating fragment. 2, 6, 13, 14, 16.
363. *O. amphibia* C. A. Agardh. Common, on mud, moist soil and aquatic plants. 2, 8, 12, 13, 16. Fla., La., N. C.
364. *O. brevis.* Kütz. Rare, on moist sand. 14. Fla., La., N. C.
365. *O. limosa* (Roth) C. A. Agardh. Frequent, floating fragments and attached. 4, 6, 12. La., N. C.
366. *O. princeps* Vauch. Frequent, floating scum and on mud. 9, 11, 12, 16. Fla., La., N..C.
367. *O. prolifica* (Grev.) Gomont. Rare, on mill house boards. 13. N. C.
368. *O. splendida* Greville. Infrequent, mud scum and in pig wallow. 10, 16. Fla., N. C.
369. *O. subtilissima* Kütz. Rare, in watering trough. 16. N. C.
370. *O. tenuis* C. A. Agardh. Common, free floating and attached. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16. Fla., La., N.C. A very widespread blue-green, especially in the tycho-plankton.
371. *Phormidium* sp. Frequent, on submerged rocks and stumps. 2, 4, 13.
372. *P. retzii* (C. A. Agardh) Gomont. Infrequent, on dam and water spillway. 6, 13. Fla., La., N. C.
373. *Lyngbya* sp. Common, floating fragments and entangled in stems. 1, 4, 9, 10, 15.
374. *L. diguetii* Gomont. Rare, in strainings. 4. Fla., N. C.
375. *L. martensiana* Meneg. Rare, in strainings. 6. Fla., N. C.

28. NOSTOCACEAE

376. *Anabaena* sp. Common, free floating and entangled with other algae. 2, 3, 5, 8, 9, 11, 12, 14, 16.
377. *A. affinis* Lemm. Rare, in strainings and squeezings. 9. N. C.
378. *A. catenula* (Kütz.) Bornet and Flahault. Infrequent, free floating. 5, 14. Fla.
379. *A. flos-aquae* (Lyngb.) Bréb. Infrequent, in strainings. 2, 11. Fla., Miss., N. C.
380. *A. lemmermanni* Richter. Infrequent, in strainings. 2, 11. New.
381. *A. levanderi* Lemm. Rare, in squeezings. 5. New.
382. *Anabaenopsis* sp. (?) Rare, entangled with green filaments. 15. New.
383. *Aphanizomenon flos-aquae* (L.) Ralfs. Rare, in strainings. 10. N. C.
384. *Cylindrospermum* sp. Infrequent, entangled with *Riccia* and aquatic plants. 3, 15.
385. *C. majus* Kütz. Infrequent, entangled masses about aquatic plants. 15, 16. N. C.
386. *C. minutissimum* Collins. Rare, in squeezings. 7. N. C.

29. SCYTONEMATACEAE

387. *Scytonema* sp. Common, free floating and in squeezings. 4, 6, 7, 9, 10, 16.
388. *S. archangelii* Bornet and Flahault. Rare, in strainings. 11. Fla., N. C.
389. *Tolypothrix lanata* Wartmann. Infrequent, in strainings and on submerged stems. 10, 16. Fla., N. C.
390. *T. tenuis* Kütz. Frequent, in strainings and on aquatic stems and roots. 1, 5, 10, 12. Fla., N. C.
391. *Microchaete tenera* Thuret. Infrequent, in strainings. 2, 8. Fla., N. C.

30. STIGONEMATACEAE

392. *Hapalosiphon* sp. Frequent, floating fragments and attached to aquatic vegetation. 3, 8, 9.
393. *H. hibernicus* W. West and G. S. West. Common, floating fragments and attached to aquatic vegetation. 1, 2, 3, 5, 6, 8, 10, 11, 14. Fla., N. C.
394. *H. pumilus* (Kütz.) Kirchner. Rare, on floating stick. 16. Fla.
395. *Stigonema ocellatum* (Dillw.) Thuret. Rare, floating and on submersed stems. 16. S. C.

31. RIVULARIACEAE

396. *Calothrix* sp. Infrequent, in squeezings. 5, 11.
397. *Rivularia natans* (Hedwig) Welwitsch. Rare, in strainings and squeezings. 11. New.
398. *Gloeotrichia echinulata* (J. E. Smith) Richter. Frequent, in strainings and squeezings. 8, 11, 16. N. C., S. C.
399. *G. pisum* (C. A. Agardh) Thuret. Rare, on submerged stems. 16. Fla.

SUMMARY

The purpose of this survey was to present a qualitative and quantitative study of the plankton algae of Southwestern Georgia. The qualitative collections were limited only by the boundaries of the eleven counties shown in fig. 1, whereas the quantitative samples were restricted to fifteen ponds. Fifteen months were spent in the field gathering the necessary material.

A total of 399 species and varieties, 93 genera and 31 families was determined. 207 species represent new records for the state of Georgia and 85 species are reported for the first time for the Southeastern Coastal Plain. Some of the more noteworthy finds are *Chrysopyxis bipes, Coelastrum chodati, Dinobryon divergens, Peridinium limbatum, Phymatodocis nordstedtiana* and *Pleurotaenium spinulosum.*

The genera represented by the largest number of species are as follows: Cosmarium, 43; Staurastrum, 41; Closterium, 29; Euastrum, 23; Micrasterias, 23; Scenedesmus, 15.

The families with the largest number of species are the following: Desmidiaceae, 211; Oocystaceae, 34; Chroococcaceae, 23; Scenedesmaceae, 18; Oscillatoriaceae, 15.

Babcock Pond had the richest flora with 114 species of plankton algae. Those ponds approaching this number are Big Cypress, 111; Cane Water, 93; Putney, 89; Mossy, 88 and Porter, 88. The two mill ponds, Sheffield's and Ivy's, had the lowest number with 29 and 32 respectively.

The qualitative findings are presented in an annotated list, while the quantitative results are recorded graphically by months for each pond. Blooms of *Dinobryon divergens* and *Microcystis aeruginosa* were noted during the winter and summer months respectively.

An attempt was made to classify the ponds on a basis of the number and variety of algae found therein, with particular emphasis being placed on the Desmidiaceae. This resulted in the establishment of three groups. Group one was characterized by having limited quantitative numbers of algae, a rather even seasonal distribution and a wide variety of species, especially among the desmids. The second group likewise possessed a large variety of desmid species but had a phyto-plankton population which was generally rich in numbers and exhibiting marked seasonal pulsations. The final group has the intrinsic property of being desmid-poor while having relatively high

numbers of diatoms and blue-greens. Members of group three had clear cool waters and sandy bottoms whereas those ponds in groups one and two had warm dark waters and mucky organic bottoms.

REFERENCES

AMER. PUB. HEALTH ASSOC. 1946—Standard methods for examination of water and sewage. New York.

BAILEY, J. W. 1851—Microscopical observations made in South Carolina, Georgia and Florida. Smithson. Inst. Contr. Knowl. 2(8):1-48.

BORGE, O. 1909—Nordamerikanische Suesswasseralgen. Ark. Bot. 8(13):1-29.

BROWN, HELEN J. 1930—The Desmids of the Southeastern Coastal Plain of the United States. Trans. Amer. Micro. Soc. 49(2):97-139.

BRADLEY, G. H. 1932—Some Factors Associated with the Breeding of Anopheles Mosquitoes. J. Agric. Res. 44(5):381-399.

BRUNEL, J. 1949—The rediscovery of the desmid *Pleurotaenium spinulosum* with description of a new variety from Madagascar. Cont. de l'Institute Botanique de l'Universite de Montreal. No. 64:3-19.

COCKE, E. C. 1949—The Myxophyceae of North Carolina. J. Elisha Mitchell Soc. 65:71-89.

COLLINS, F. S. 1909—The green algae of North America. Tufts College Studies, Sci. Ser. 2:79-480.

CROWSON, DOROTHY E. 1950—The algae of a modified brackish pool. Quar. J. Fla. Acad. Sci. 13(1-4):133-141.

FROHNE, W. C. 1939—Suggested classification of ponds based on characteristic desmids. Pub. Health Rep. 54(30):1363-1387.

———1942—Reconnaissance of anopheline larval habits and characteristic desmids of the Okefenokee Swamp, Georgia. Pub. Health Rep. 57(33):1209-1217.

———1942—Notes on *Phymatodocis Nordstedtiana* from South Carolina and its variety *minor* Boergesen from Georgia. Trans. Amer. Micro. Soc. 61:438-441.

IRÉNÉE-MARIE, FR. 1938—Flore Desmidiale de la Region de Montreal. Pp. 547, pl. 69. Laprairie, Canada.

MADSEN, GRACE C. AND C. S. NIELSEN 1950—Check list of the algae of northern Florida II. Quart. J. Fla. Acad. Sci. 13(1-4):2-21.

PASCHER, A. 1913-1927—Die Süsswasserflora Deutschlands, Österreichs und der Schweiz. Nos. 1-7, 9, 11, 12. Jena.

PHILSON, P. J. 1939—Fresh-water algae of North and South Carolina I. Cyanophyceae. J. Elisha Mitchell Soc. 57:83-116.

PRESCOTT, G. W. 1942—The Fresh-water algae of southern United States. II. The algae of Louisiana, with descriptions of some new forms and notes on distributions. Trans. Amer. Micro. Soc. 61(2):109-119.

———1948—Bot. Rev. 14(1):644-676.

———1951—Algae of the Western Great Lakes Area. Cranbrook Institute of Science, Bull. No. 31. Bloomfield Hills, Mich.

———AND A. M. SCOTT 1942—The Fresh-water algae of southern United States I. Desmids from Mississippi with descriptions of new species and varieties. Trans. Amer. Micro. Soc. 61(1):1-29.

———AND———1942—The Desmid Genus *Micrasterias* Agardh in Southeastern United States. Papers Mich. Acad. Sci. Arts and Letters. 38:67-82, pl. 1-6.

———AND———1945—The fresh-water algae of the southern United States III. The desmid genus *Euastrum*. Amer. Mid. Nat. 34(1):231-257.

———AND———1952—The algal flora of southeastern United States V. Additions to our knowledge of the desmid genus *Micrasterias* 2. Trans. Amer. Micro. Soc. 71:229-252.

SALISBURY, R. K. 1936—The desmids of Florida. Ohio. J. Sci. 36(1):55-61.

SCOTT, A. M. AND G. M. PRESCOTT. 1952—The algal flora of southeastern United States VI. Additions to our knowledge of the desmid genus *Euastrum*. Hydrobiologia 4(4):377-398.

SILVA, H. 1948—A review of fresh-water phycological research in southeastern United States. Castanea 13(4):133-141.

———1949—Additions to the algae of the southeastern United States. J. Elisha Mitchell Sci. Soc. 65(1):90-109.

SMITH, G. M. 1920—Phytoplankton of the inland lakes of Wisconsin. Bull. Wisc. Geo. and Nat. Hist. Surv. No. 57. Part I. Madison, Wisc.

———1924—Phytoplankton of the inland lakes of Wisconsin. *Ibid*. Part 11. Madison, Wisc.

———1950—The Fresh-water algae of the United States. McGraw Hill, New York.

THOMPSON, R. H. 1947—Fresh-water Dinoflagellates of Maryland. Chesapeake Bio. Lab. Pub. No. 67. Solomons Is., Md.

THORNE, R. F. 1949—The flora of southwestern Georgia. A thesis. Cornell University, Ithaca, New York.

TIFFANY, L. H. 1930—The Oedogoniaceae. Pub. by the Author. Columbus, Ohio.

———1937—Oedogoniales—Oedogoniaceae. N. Amer. Flora 11(1). N. Y. Bot. Gard., N. Y.

TILDEN, JOSEPHINE E. 1910—Minnesota algae, Vol. 1, Myxophyceae. Minneapolis, Minn.

WEST, W. AND G. S. WEST 1898—Some desmids of the United States. J. Linn. Soc. Bot. 33:279-322.

———AND———1904-1923—A monograph of British Desmidiaceae. 5 Vols. Adland and Son, London.

WHELDEN, R. M. 1941—Some observations on the Fresh-water algae of Florida. J. Elisha Mitchell Soc. 55:83-116.

WHITFORD, L. A. 1943—The Fresh-water algae of North Carolina. *Ibid*. 59(2):131-170.

———1950—Some fresh-water algae from Mississippi. Castanea 15:117-123.

WOLLE, F. 1884—Desmids of the United States. Bethlehem, Pa.

———1887—The Fresh-water algae of the United States. Bethlehem, Pa.

WOOD, H. C. 1874—A Contribution to the history of the fresh-water algae of the United States. Smith. Contrib. to Know. 19:1-262.

Florida Scytonemataceae II[1]

C. S. Nielsen and Grace C. Madsen
Florida State University, Tallahassee

Collection records and reports from Florida of the various species of this family have been published in a previous paper (Nielsen and Madsen, 1956). These included the specimens known to the authors with the exception of the species of *Scytonema*. It is the object of this report to include the latter. Explanations concerning abbreviations of specimen locations, earliest Florida collections on record and the authors' grateful acknowledgement to Dr. Francis Drouet of the Chicago Natural History Museum for species determinations and general assistance is referred to the reference cited above.

Key to the Species of Scytonema

Section I. Sheaths homogeneous or forming a parallel stratum; cell walls distinctly conspicuous ..... Euscytonema

A. Aquatic, filaments free ..... B

B. Discoid cells 3-4 times shorter than trichome diameter C

C. Fresh-water plants everywhere forming entangled lyngbyoid filaments, sparingly pseudo-branched, 18-30μ wide; trichomes dark green ..... 1. *S. cincinnatum*

BB. Cell length often equal to or longer than diameter; fresh water plants ..... D

D. Caespitose, radiating expanse, brilliant green, filaments 18-24μ wide. ..... 2. *S. coactile*

AA. Terrestrial ..... E

E. Filaments 15μ or more wide ..... F

F. Dense, caespitose, black-green, filaments united into erect fascicles, 1-1.5 mm high, 15-21μ wide; cells subquadrate, olive-green, younger violet to bluish-gray ..... 3. *S. guyanense*

FF. Pulvinate, tomentose, black-violet to reddish; filaments free 5-10 mm long, 16-30μ wide; sheaths wide, gelatinose; cells ½ trichome diameter, occasionally subequal ..... 4. *S. stuposum*

EE. Filaments up to 15μ wide ..... G

G. Caespitose, blue-green to reddish; filaments united into fascicles, 2-4 mm high, 12-15μ wide, flexuous ..... 5. *S. javanicum*

GG. Tomentose, dark blue-green; filaments free, 6-10 mm high, 9-15μ wide; sheaths gelatinose, cells blue-green ..... 6. *S. varium*

GGG. Caespitose, black, bluish-gray to dark blue; filaments 1-3 mm high, united into fascicles, 7-15μ wide ..... 7. *S. Hofmannii*

EEE. Filaments 10-18μ wide ..... H

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HH. Dense, caespitose, black to ash-gray or dark blue; filaments free 1-2 mm high, 10-18μ wide; sheaths thin and fragile, dark; cells olive-green ..... 8. *S. ocellatum*

SECTION II. Sheaths lamellose, layers diverging; branches generally geminate, arising at right angles ..... Myochrotes

A. Caespitose, floating, radiating expanse; filaments 10-15μ wide; sheaths sparingly lamellose ..... 9. *S. tolypotrichoides*

AA. Terrestrial, pannose expanse; filaments 15-21μ wide; sheaths here and there lamellose, narrow toward vertex of distal cells ..... 10. *S. figuratum*

AAA. Terrestrial, pannose expanse; filaments 18-36μ wide; sheaths continuously wide to vertex of distal cells; many ocreate ..... 11. *S. Myochrous*

SECTION III. Sheaths wide, lamellose, forming many ocreate layers; branching of 2 types: lower branches geminate (scytonematoid), superior solitary (tolypotrichoid), provided with basal heterocysts ..... Petalonema

A. Caespitose, crustaceous, black; filaments 0.5-2 mm high, 15-30μ wide; geminate branches uniting below, above free ..... 12. *S. crustaceum*

AA. Pulvinate, black; filaments free, one mm high, 27-45μ wide; sheaths extremely lamellose, eroded ..... 13. *S. crassum*

1. SCYTONEMA CINCINNATUM Bornet & Flahault

Fig. 1

Filaments measured from 18.5 to 24.5μ in width; trichome diameter 14.5 to 22μ.

The species has been reported for the state by Wolle (1887) and Tilden (1910) as *S. crispum* (Agardh) Bornet (Drouet, 1939) and by Brannon (1952).

FLORIDA: *Smith*, Mar. 1878 (N). ALACHUA CO.: in Hogtown creek, west of golf course, Gainesville, *W. R. Caroll* 122, Nov. 1942 (C, U); Gainesville, *Brannon* 292, 20 Mar. 1945 (C, U). LEON CO.: pond, Meridian Rd., 5 miles north of Tallahassee, *E. Deviney* 1, 2, 10, Nov. 1952 (C, F). MANATEE CO.: in Bradenton River, just above dam, Bradenton, *Cloyd B. Stifler*, Apr.-May 1946 (C).

2. SCYTONEMA COACTILE Bornet & Flahault

Fig. 2

Filaments averaged about 21μ in width; trichome diameter 15μ.

The species has been reported for the state by Brannon (1945, 1952).

ALACHUA CO.: in Sink I, Hibiscus Pk., Gainesville, *Brannon* 10, 17 Sept. 1941 (C, U); 81 27 July 1942 (C, U). CITRUS CO.: Lake Tsala Apopka, Hernando, *Brannon* 88, 90, 9 Aug. 1942 (C, U). DADE CO.: in quarry southwest of Coral Gables, *R. P. Hodge* 6, 20 Nov. 1935 (C). LAKE CO.: Leesburg, *Brannon* 331, 31 May 1948 (C, U). MANATEE CO.: in Bradenton River just above dam, Bradenton, *Cloyd B. Stifler*, Apr.-May 1946 (C). ORANGE CO.: Orlando, *Brannon* 339, 31 May 1948 (C, U).

3. SCYTONEMA GUYANENSE Bornet & Flahault

Fig. 3

Filaments varied from 17 to 19μ in width; trichome diameter averaged about 12 μ.

The species has been reported for the state by Tilden (1910), Nielsen & Madsen (1948a) and Brannon (1952). It occurs with *Nostoc micro-*

scopicum B. & F., *Scytonema Hofmannii* B. & F., *Sirogonium sticticum* (Engl. Bot.) Kütz. and *Trentepohlia* spp.

FRANKIN CO.: in depression in kitchen midden beside St. George sound about 2 miles east of Eastpoint, *Drouet & Nielsen* 10951, 10952, 16 Jan. 1949 (C, F). GADSDEN CO.: Little River, U. S. Highway 90, 8 miles east of Quincy, *Nielsen* 1431, 9 July 1949 (C, F). HILLSBOROUGH CO.: Hillsborough State Pk., *P. O. Schallert* 1151, 8 Mar. 1947 (C, W). JACKSON CO.: Fla. Caverns State Pk., Marianna, *Nielsen & Madsen* 327, 328, 31 Aug. 1948 (C, F); on limestone, entrance to cave, Fla. Caverns State Pk., Marianna, *Drouet, Nielsen, Madsen & Crowson* 10358, 10389, 10401, 4 Jan. 1949 (C, F); on cliff face, Fla. Caverns State Pk., Marianna, *C. Jackson*, 10 Dec. 1950 (C, F). LAKE CO.: ground, greenhouse exp. sta., Leesburg, *Brannon* 251, 252, 28 July 1944 (C, F). LEON CO.: Natural Well, 1 mile southeast of Woodville, *Nielsen & Madsen* 586-588, 30 Oct. 1948 (C, F); on discarded bricks, open woods west of power plant, F.S.U. campus, *Drouet & Crowson* 10440, 5 Jan. 1949 (C, F); on walls of Natural Well, a limestone sinkhole about 1 mile southeast of Woodville, *Drouet, Crowson & Thornton* 11321, 11324, 11326, 25 Jan. 1949 (C, F); on red clay, Jackson Bluff, Ochlockonee River, *C. Jackson*, 9 Nov. 1950 (C, F). LIBERTY CO.: Apalachicola River flood plain at Bristol, *Nielsen & Madsen* 430, Aug. 1948 (C, F); on limestone cliffs of flood plain, Apalachicola River at Aspalaga, *Nielsen, Madsen & Crowson* 739, 12 Feb. 1949 (C, F). OSCEOLA CO.: north of Kissimmee, *P. C. Standley* 92728, 16 Mar. 1946 (C). WAKULLA CO.: on decaying log in swamp, St. Mark's River, Newport, *Drouet, Madsen & Crowson* 10789, 13 Jan. 1949 (C, F); on bases of trees in St. Mark's River, Newport, *Drouet, Madsen & Crowson* 10799, 10801, 13 Jan. 1949 (C, F); on wet ground beside "log sulphur spring" in woods along St. Mark's River, 1 mile north of Newport, *Drouet, Crowson & Thornton* 11332, 11333, 25 Jan. 1949 (C, F); on soil at edge of Phillip's Pool, Port Leon, *C, Jackson*, 11 Nov. 1950 (C, F); on sand at Cleb's Pool, *A. H. Johnston* 86, 11 Nov. 1950 (C, F). WASHINGTON CO.: on soil, edge of limestone pit, Falling Water, 5 miles south of Chipley, *A. H. Johnston* 26, 28, 14 Jan. 1951.

4. SCYTONEMA STUPOSUM Bornet & Flahault

Fig. 4

Filaments measured from 16 to 21μ in width; trichome diameter averaged about 17μ.

This species was collected in Florida by J. Donnell Smith, Mar. 1878 (N) and reported by Wolle (1887) and Tilden (1910) as *S. intertextum* Kütz.) Rabenhorst (Drouet, 1939).

5. SCYTONEMA JAVANICUM Bornet & Flahault

Fig. 5

Filaments measured about 13μ in width; trichome diameter varied from 9 to 10μ.

ALACHUA CO.: in moss on walls of greenhouse, *Brannon* 417, 4 Apr. 1947 (C, U). WAKULLA CO.: Spillway Pond, Phillip's Pool, St. Mark's Wildlife Refuge, *Drouet, Madsen & Crowson* 942, 26 Jan. 1949 (C, F).

6. SCYTONEMA VARIUM Bornet & Flahault

Fig. 6

Filaments measured 7.5-8μ in width; trichome diameter 6.5 to 7.5μ.

POLK CO.: Fort Meade, *Smith*, May 1880 (C, N). ST. JOHNS CO.: Anastatia Island, St. Augustine.

The species was reported by Wolle (1887) and by Tilden (1910) as *Scytonema chrysochlorum* Kg.

7. SCYTONEMA HOFMANNII Bornet & Flahault

Fig. 7

The width of filaments varied from 7.5 to 12μ; trichome diameters measured from 6 to 8.5μ.

The species has been reported for the state by Wolle (1887), Tilden (1910), Nielsen & Madsen (1948a) and Brannon (1952). It commonly occurs with other algae; most numerous among the cited specimens were *Gloeocapsa alpicola* (Lyngb.) Born., *Microcoleus* spp., *Nostoc* spp., *Porphyrosiphon fuscus* Gom., *Schizothrix purpurascens* Gom., *Scytonema guyanense* B. & F., *S. Myochrous* B. & F., *Stigonema panniforme* B. & F. and *Trentepohlia* spp.

FLORIDA: St. Lucian River, *Smith*, Mar. 1878 (C, P); on *Myrica cerifera*, *H. W. Ravenel* 10, (C, P); *Smith*, 1878 (C, N, P). ALACHUA CO.: on *Myrica cerifera*, Gainesville, *H. W. Ravenel* 37, (C); Gainesville, *Brannon* 114, 13 Oct. 1942 (C); Gainesville, *W. R. Carroll* 265, Aug. 1944 (C, U); Gainesville, *Brannon* 266, 12 Aug. 1944 (C). BAKER CO.: Olustee, *Brannon* 227, 1 May 1944 (C). CALHOUN CO.: along Fla. Highway 71, 2 miles north of Altha, *Nielsen & Kurz* 908, 19 Feb. 1949 (C, F); along Fla. Highway 20, Taluga River, *Nielsen & Madsen* 868, 21 Feb. 1949 (C, F). DADE CO.: Cocoanut Grove, Miami, *Roland Thaxter* 7795, 7798, 23 Jan. 1898 (C, Maxwell C. Doty); Cox Hammock, *J. K. Small & C. A. Mosier* 5835, 25 Feb. 1915 (C, Y); northeast face of vertical wall, James Deering estate on S.W. 32 Rd., Miami, *H. J. Humm*, 14 Nov. 1948 (C); on decayed avacado wood, 5 miles west of Goulds, *C. Jackson* 3, 6, 15 July 1952 (C, F); on oolitic limestone in open field, 5 miles west of Goulds, *C. Jackson* 8, 15 July 1952 (C, F); on cement walk, 5 miles west of Goulds, *C. Jackson* 1, 15 July 1952 (C, F); in cypress dome, 5 miles south of Royal Palm Pk., Flamingo Rd., *Blake & Hauke*, 3 Feb. 1953 (C, F); in mangrove swamp near station no. 7, Everglades Nat'l. Pk., *Blake & Hauke*, 3 Feb. 1953 (C, F). FRANKLIN CO.: on stumps and roots of palmetto, shore of Apalachicola Bay, S.E. part of Apalachicola, *Drouet & Nielsen* 10976, 16 Jan. 1949 (C, F); on roots of palmetto, north shore of St. Vincents Sound, about 10 miles west of Apalachicola, *Drouet & Nielsen* 10978, 16 Jan. 1949 (C, F). GADSDEN CO.: Apalachicola River at Chattahoochee, *Nielsen, Madsen & Crowson* 288-292, 31 Aug. 1948 (C, F); on flood plain and limestone cliffs, Aspalaga on Apalachicola River, *Nielsen, Madsen & Crowson* 738, 740, 746, 750, 784, 12 Feb. 1949 (C, F); at Little River on U. S. Highway 90, 8 miles east of Quincy, *Nielsen* 1412, 1413, 1416-1424, 9 July 1949 (C, F); on Apalachicola River flood plain, U. S. Highway 90 at Chattahoochee, *Nielsen* 1438, 1444, 9 July 1949 (C, F); at Aspalaga on Apalachicola River, *Nielsen* 3011, 15 Apr. 1950 (C, F); on living oak, wooded area, surface of moist limestone, in gulley, Aspalaga on Apalachicola River, *Voth & Harmon* 3, 4, *Voth* 7, 9, *Harmon* 19, 25, 26, *Johnston* 40, 46, 51, 62, 67, 4 Nov. 1950 (C, F). HOLMES CO.: bank of Choctawhatchee River, 5 miles north of Westville, *Nielsen* 301-303, 7 Aug. 1952 (C, F). JACKSON CO.: Fla. Caverns State Pk., Marianna, *Nielsen & Madsen* 323, 330, 31 Aug. 1948 (C, F); along Fla. Highway 71, 2 miles south of Marianna, *Nielsen & Madsen* 336, 337; 5 miles south of Marianna, *Nielsen & Madsen* 349, 31 Aug. 1948 (C, F); on rotting log along Chipola river, Fla. Caverns State Pk., *Drouet, Nielsen, Madsen & Crowson* 10351, 4 Jan. 1949 (C, F); wayside pk., U. S. Highway 90, 1 mile west of Cottondale, *Nielsen & Madsen* 856, 19 Feb. 1949 (C, F); on walk, Fla. Caverns State Pk., *R. W. Wilson* 406, 28 July 1952 (C, F). JEFFERSON CO.: Judge Hopkin's Camp, Lake Miccosukee, *Nielsen & Crowson* 962, 972, 11 Mar. 1949 (C, F). LAKE CO.: at Eustis, *W. G. Farlow*, (C, M. C. Doty). LEON CO.: Natural Well, 1 mile southeast of Woodside, *Nielsen, Madsen & Crowson* 111-114, 121, June 1948 (C, F); St. Mark's River at Little Natural Bridge, *Nielsen, Madsen & Crowson* 144, 146, 149, 151, 159, June 1948 (C, F); at pond, on Fla. Highway 10, 16 miles northwest of Tallahassee, *Nielsen & Crowson* 263, June 1948 (C, F); on roadside bank, west of F. S. U., Tallahassee, *Drouet & Crowson* 10442, 10462, 5 Jan. 1949 (C, F); on log along Ochlockonee river at U. S. Highway 90, west of Stephensville, *Drouet, Crowson*

& *Petersen* 10495, 6 Jan. 1949 (C, F); magnolia woods near northwestern shore of Lake Iamonia, *Drouet, Kurz & Nielsen* 11272a, 11287, 11308, 24 Jan. 1949 (C, F); barren ground, edge of cypress swamp, Fla. Highway 61, north of Leon-Wakulla Co. line, *Drouet, Madsen & Crowson* 11536, 27 Jan. 1949 (C, F); at Jackson Bluff power station, Fla. Highway 20, *Nielsen & Kurz* 901, 19 Feb. 1949 (C, F). LEVY CO.: on bank in open woods, Fla. Highway 20, 1 mile east of Sumner, *Drouet & Nielsen* 11207, 23 Jan. 1949 (C, F). LIBERTY CO.: flood plain, Apalachicola River at Bristol, *Nielsen & Madsen* 424, Aug. 1948 (C, F); along Fla. Highway 20, 28 miles west of Tallahassee, *Nielsen & Kurz* 905, 19 Feb. 1949 (C, F); along Fla. Highway 20 at Hosford, *Nielsen & Kurz* 87, 19 Feb. 1949 (C, F). MARION CO.: dried pool, Ocala Nat'l. Forest, *P. C. Standley* 92783, 17 Mar. 1946 (C); on wood of floating dock, west shore of Orange Lake, McIntosh, *Drouet & Brannon* 11099, 21 Jan. 1949 (C, F). ORANGE CO.: Rock Spring Pk., *P. O. Schallert* 1662, 2 Apr. 1948 (C, W). PALM BEACH CO.: on stump, Palm Beach, *Roland Thaxter* 7799, Dec. 1897 (C, M. S. Doty); Palm Beach, *Roland Thaxter* 1898-99 (C, H); on trunks of Australian pine in Pineway east of county rd., Palm Beach, *Drouet & Louderback* 10213, 24 Dec. 1948 (C, F). POLK CO.: on cement in field, Hesperides, 9 miles east of Lake Wales, *Drouet, Brannon & Tilden* 11088, 20 Jan. 1949 (C, F). SANTA ROSA CO.: in depression in sand dunes, east of Pensacola beach, *Drouet, Madsen, Nielsen, Crowson & Pates* 10592, 8 Jan. 1949 (C, F). WAKULLA CO.: at Club Springs, Newport, *Nielsen, Madsen & Crowson* 227, Aug. 1948 (C, F); on decaying log in swamp beside St. Mark's River, Newport, *Drouet, Madsen & Crowson* 10789, 13 Jan. 1949 (C, F); on high eroded bank of East River, west of St. Mark's Lighthouse on Gulf of Mexico, mouth of St. Mark's River, *Drouet, Madsen & Crowson* 11733, 11739, 11743, on rock on ridge between East River and lighthouse pool, *Drouet, Madsen & Crowson* 11756, 1 Feb. 1949 (C, F); on rotting log, Sulphur Springs, Newport, *C. Jackson*, 11 Nov. 1950 (C, F). WASHINGTON CO.: along highway 5 miles east of U. of Fla. Egg-Laying sta., Chipley, *Nielsen & Madsen* 866, 867, 19 Feb. 1949 (C, F); in and about large limestone pit, Falling Water, 4 miles south of Chipley, *M. H. Voth* 501, 502, *A. H. Johnston* 27, 33, *C. Jackson* 601, 602, *Nielsen* 603, 604, 14 Jan. 1951 (C, F).

Scytonema cortex var. *corrugatum* Wolle (*J. Donnell Smith*, Mar. 1878) and *Sirosiphon scytonematoides* Wood (*Ravenel* 10) have been referred to *Scytonema Hofmannii* B. & F. (Drouet, 1939).

8. SCYTONEMA OCELLATUM Bornet & Flahault

Fig. 8

Filament width averaged about 12μ; trichome diameter averaged about 7μ.

The species has been reported for the state by Tilden (1910), Taylor (1928), Brannon (1945, 1952) and Nielsen and Madsen (1948b). It has been found with *Gloecapsa alpicola* (Lyngb.) Born., *Microcoleus chthonoplastes* Gom., *Porphyrosiphon Notarisii* Gom. and *Schizothrix* spp.

ALACHUA CO.: Hibiscus Pk., Gainesville, *Brannon* 139, 188, 189, Jan. 1943 (C, U); Gainesville, *Brannon* 239, 21 July 1944 (C, U); *Brannon* 337, 7 May 1946 (C, U). BAY CO.: above hightide mark on shore of west arm of St. Andrews Bay, West Bay, *Drouet & Nielsen* 10858, 15 Jan. 1949 (C, F). COLLIER CO.: Marco Island, *P. C. Standley* 92839, 14 Mar. 1946 (C). FRANKLIN CO.: barren ground in open pine woods, southwest of Eastpoint, *Drouet & Nielsen* 11662, 31 Jan. 1949 (C, F). GADSDEN CO.: trees in upland woods beside U. S. Highway 90, 4 miles east of Quincy, *Drouet, Nielsen, Madsen, Crowson & Pates* 10422, 10427, 4 Jan. 1949 (C, F); on barren ground, 4 miles east of Quincy, *Drouet, Nielsen, Madsen & Crowson* 10410, 4 Jan. 1949 (C, F). HIGHLANDS CO.: Highland Hammock State Pk., *P. C. Standley* 92684, 15 Mar. 1946 (C). JACKSON CO.: Fla. Caverns State Pk., Marianna, *Nielsen & Madsen* 318, 31 Aug. 1948 (C, F); on rocks about headquarters bldg., Fla. Caverns State Pk., *Drouet, Nielsen, Madsen & Crowson* 10370, 4 Jan. 1949 (C, F). JEFFERSON CO.: Judge Hopkin's Camp, Lake Miccosukee, *Nielsen & Crowson* 955, 11 Mar. 1949 (C, F). LAKE CO.: on curbstone of st., Municipal Pk., Leesburg, *Drouet & Brannon* 11041, 19

Jan. 1949 (C, F). LEE CO.: on bark, region of Hendry Creek, about 10 miles south of Fort Myers, *P. C. Standley* 73425, 11-25 Mar. 1940 (C); on white sand, south of Bonita Spgs., *Julian A. Steyermark* 63180a, 10 Mar. 1946 (C). LEON CO.: Meridian Rd., 18 miles north of Tallahassee, *Nielsen & Madsen* 377, 31 Aug. 1948 (C, F); on eroded clay bank, Meridian Rd. between Lake Iamonia and Ochlockonee River, *Drouet, Kurz & Nielsen* 11267a, 24 Jan. 1949 (C, F); in ditch on U. S. Highway 27, Tallahassee north city limit, *A. H. Johnston* 1518, 11 Aug. 1949 (C, F). LEVY CO.: in upland sand barrens, N.W. part of Way Key, Cedar Keys, *Drouet & Nielsen* 1173, 22 Jan. 1949 (C, F). LIBERTY CO.: along Fla. Highway 20, 28 miles west of Tallahassee, *Nielsen & Kurz* 906, 19 Feb. 1949 (C, F). MONROE CO.: deep green, on moist mud in marsh S.W. of artificial lake, Big Pine Key, *E. P. Killip* 42002, 14 Mar. 1952 (C, N). PALM BEACH CO.: on cement walks by Royal Poinciana Blvd., east of Flagler Mem. Bridge, Palm Beach, *Drouet & Louderback* 10215, 10216, 24 Dec. 1948 (C, F). SANTA ROSA CO.: in depression in sand dunes, east of Pensacola, *Drouet, Nielsen, Madsen, Crowson & Pates* 10583, 10605, 8 Jan. 1949 (C, F). WAKULLA CO.: Phillip's picnic grounds, Newport, *Nielsen, Madsen & Crowson* 191, July 1948 (C, F); on bark of tree, south side of spring pool, Wakulla Spgs., *Drouet, Madsen & Crowson* 11499, 21 Jan. 1949 (C, F); on rocks above tide mark beside St. Mark's River, Port Leon, *Drouet & Atwood* 11460, 26 Jan. 1949 (C, F); on high eroded bank of East River, west of St. Mark's Lighthouse, on Gulf of Mexico at mouth of St. Mark's River, *Drouet, Madsen & Crowson* 11737, 1 Feb. 1949 (C, F).

The *Scytonema cinereum* Menegh. reported by Wolle (1887) for the state has been referred to *Scytonema ocellatum* B. & F. (Drouet, 1939).

9. SCYTONEMA TOLYPOTRICHOIDES Bornet & Flahault

Fig. 9

Trichome diameters averaged 9.5μ.

The species has been reported for the state by Wolle (1887), Nielsen & Madsen (1948b), Crowson (1950) and Brannon (1952). It has been found to occur frequently with *Hapalosiphon pumilus* B. & F., *Cosmarium* spp., *Spirogyra* spp. and *Zygnema* spp.

FLORIDA: *J. Donnell Smith*, Mar. 1878 (P, N). ALACHUA CO.: in lake, Melrose, *Brannon* 308, 311, 5 Aug. 1945 (C, U). CITRUS CO.: Lake Tsala Apopka, Hernando, *Brannon* 85, 87, 89, 92, 9 Aug. 1942 (C). DADE CO.: quarry on 79th St. N.W., Miami, *Ruth Patrick*, Jan. 1939 (C). GULF CO.: in ditch, 2 miles south of Port St. Joe, U. S. Highway 98, *A. H. Johnston* 1520, 13 Aug. 1949 (C, F). HENDRY CO.: in Everglades, 7 miles south of La Belle, *J. E. Davis* 20, Oct. 1941 (C, U). LAKE CO.: in shallow water of pond, 14th & Center Sts., Leesburg, *Drouet & Brannon* 11067, 11071, 11082, 11083, 11086, 19 Jan. 1949 (C, F, U). LEE CO.: on moist sand, region of Hendry Creek, about 10 miles south of Fort Myers, *P. C. Standley* 73460, 11-25 Mar. 1940 (C); dried swamp, Bonita beach, *P. C. Standley* 73224, 14 Mar. 1940 (C). LEON CO.: on U. S. Highway 319, 5 miles south of Tallahassee, *Nielsen, Madsen & Crowson* 82, May 1948 (C, F); in pool near Ochlockonee River at U. S. Highway 90, west of Stephensville, *Drouet, Crowson & Petersen* 10498, 6 Jan. 1949 (C, F). MONROE CO.: deep green, marshy places, stunted buttonwood stand, west of artificial lake, Big Pine Key, *E. P. Killip* 41908, 9 Feb. 1952 (C). ORANGE CO.: Lake I, Orlando, *Brannon* 336, 31 May 1948 (C). TAYLOR CO.: in ditch on U. S. Highway 19, 10 miles north of Perry, *Madsen, Pates, F. Higginbotham & H. Harris* 1078, 23 Apr. 1949 (C, F). WAKULLA CO.: at Spillway Dam, Phillips Pool, St. Mark's Wildlife Refuge, *Nielsen, Madsen & Crowson* 119, July 1948 (C, F); 661, 7 Nov. 1948 (C, F); 34, 15 May 1949 (C, F); on floating log in ditch along rd. to St. Mark's Lighthouse, about 2½ miles S.E. of Newport, *Drouet, Madsen & Crowson*, 1 Feb. 1949 (C, F).

The Smith collections, reported by Wolle (1887) as *Scytonema cortex* Wood and *S. cortex f. corrugatum* Wolle, have been referred in part to *S. tolypotrichoides* B. & F. (Drouet, 1939).

10. SCYTONEMA FIGURATUM Bornet & Flahault

Fig. 10

Filament width varied from 13.5 to 19μ. Trichome diameters ranged from 7.5 to 11.5μ.

The species has been reported for the state by Wolle (1887), Nielsen & Madsen (1948a) and Crowson (1950). It occurs commonly with many other algae, among the following more frequently: *Calothrix parietina* B. & F., *Gloeocystis Grevillei* (Berk.) Dr. & Daily, *Microcoleus* spp. *Plectonema Nostocorum* Gom., *Porphyrosiphon fuscus* Gom., *P. Notarisii* Gom., *Schizothrix Heufleri* Gom., *S. Lamyi* Gom., *S. lardaecea* Gom., *S. longiarticulata* Gardn., *S. purpurascens* Gom., *Stigonema panniforme* B. & F., *Tolypothrix tenuis* B. & F. and *Zygogonium ericetorum* (Roth.) Kütz.

FLORIDA: *Smith*, Mar. 1878 (C, N). BAY CO.: at and above high water mark on shore of west arm of St. Andrew bay, *Drouet & Nielsen* 10871a, 15 Jan. 1949 (C, F). BROWARD CO.: on barren ground in circle, Hollywood Blvd., Hollywood, *Drouet & Louderback* 10257, 27 Jan. 1948 (C, F). COLLIER CO.: Marco island, *P. C. Standley* 92802, 14 Mar. 1946 (C). DADE CO.: in small pond on Douglas Rd. between Coral Gables & Cocoanut Grove, *Ruth Patrick*, Dec. 1936 (C); shallow water of cypress swamp, Tamiami Trail, *Ruth Patrick* 6, 28 Dec. 1937 (C); quarry on 79th St. N.W., Miami, *Ruth Patrick*, Jan. 1939 (C); pond in shallow excavation in coral rock along road to Royal Palm State Pk., 9 miles southwest of Homestead, *A. M. Scott* 85, 19 Oct. 1947 (C). ESCAMBIA CO.: in freshwater pool behind dunes, Gulf Beach, *Drouet, Nielsen, Madsen & Crowson* 10533, 10537, 10539, 8 Jan. 1949 (C, F). FRANKLIN CO.: in depression in kitchen midden at St. George Sound about 2 miles east of Eastpoint, *Drouet & Nielsen* 10949, 16 Jan. 1949 (C, F); in depression in sand dunes, shore of Apalachicola Bay, east end of John Gorrie Causeway, west of Eastpoint, *Drouet & Nielsen* 10959, 16 Jan. 1949 (C, F). GADSDEN CO.: open wall canyon, Aspalaga, *J. Harmon*, 7 Nov. 1950 (C, F); barren ground, upland woods beside U. S. Highway 90, 4 miles east of Quincy, *Drouet, Nielsen, Madsen & Crowson* 10420, 4 Jan. 1949 (C, F). HOLMES CO.: 5 miles north of Westville on bank of Chactawhatchee River, *Nielsen*, 4 Aug. 1952 (C, F). JACKSON CO.: in wayside pk. on U. S. Highway 90, 1 mile west of Cottondale, *Nielsen & Madsen* 853, 19 Feb. 1949 (C, F). LEE CO.: on wet sand, fresh water pool, on bark, in region of Hendry Creek, about 10 miles south of Fort Myers, *P. C. Standley* 73180a, 73243, 73246, 73350, 73354, 73361, 73364, 73411, 73539, 11-25 Mar. 1940 (C). LEON CO.: on clay bank near Ochlockonee River, U. S. Highway 90 west of Stephensville, *Drouet, Crowson & Petersen* 10481, 10483, 10486, 6 Jan. 1949 (C, F); on bank in cypress swamp, Highway 61, north of Leon-Wakulla Countyline, *Drouet, Madsen & Crowson* 11535, 27 Jan. 1949 (C, F); on barren ground at limestone sinkhole, State Highway 61, 8 miles south of Tallahassee, *Drouet, Nielsen & Madsen* 11576, 29 Jan. 1949 (C, F); along U. S. Highway 20, 15 miles west of Tallahassee, *Nielsen* 1452, 9 July 1949 (C, F). LEVY CO.: on stones in open woods, highway no. 345 about 2 miles west of Chiefland, *Drouet & Nielsen* 11215, 23 Jan. 1949 (C, F). LIBERTY CO.: in deep-cut creek, Aspalaga on Apalachicola River, *Madsen Wagner & Pates* 2053, 2055, 15 Apr. 1950 (C, F). MONROE CO.: floating in deep water, channel near bridge from Big Pine key to Torch key, *E. P. Killip* 41972, 4 Mar. 1952 (C). PUTNAM CO.: from Swan Lake, Melrose, *Brannon* 1947 (C, U). SANTA ROSA CO.: depression in sand dunes, Pensacola Beach and east of Pensacola Beach, *Drouet, Nielsen, Madsen, Crowson & Pates* 10574, 10586, 10587, 10590, 10591, 10595, 10600, 10609, 8 Jan. 1949 (C, F). SARASOTA CO.: south of Venice, *P. C. Standley* 92780, 9 Mar. 1946 (C). WAKULLA CO.: Spillway Dam, Phillips Pool, *Drouet, Madsen & Crowson* 825, 14 Jan. 1949 (C, F); on log, sulphur springs in woods along St. Mark's River, 1 mile north of Newport, *Drouet, Crowson & Thornton* 11329, 11349, 25 Jan. 1949 (C, F); on damp soil, Phillips Pool, St. Mark's Wildlife Refuge, *Crowson & Chamberlain*, 15 May 1949 (C, F); sulphur spgs., ½ mile north of Newport, *Nielsen*, 15 Oct. 1950, 23 July 1952 (C, F). WALTON CO.: roadside pool, upland pine woods,

U. S. Highway 98, 5 miles west of Walton-Bay County line, *Drouet, Nielsen, Madsen, Crowson & Pates* 10660, 9 Jan. 1949 (C, F). WASHINGTON CO.: at Falling Water, 4 miles south of Chipley, *J. F. Harmon* 14, *A. H. Johnston* 22, 37, 14 Jan. 1951 (C, F).

11. SCYTONEMA MYOCHROUS Bornet & Flahault

Fig. 11

Filaments averaged from 33 to 34μ in width; trichome diameters were approximately 12μ; heterocysts generally were subquadrate, averaging 13μ in length, 14.5μ in width.

The species was commonly mixed with *Scytonema Hofmannii* B. & F. and *Oscillatoria* spp.

FLORIDA: plants dried and somewhat lichenized. Forming a hard crust and covering extensive areas in the Everglades, near Camp Jackson, *N. L. Britton*, 25 Mar. 1904 (C, Y). GADSDEN CO.: on limestone, in creeks and ravines, Aspalaga on Apalachicola River, *Nielsen, Madsen & Crowson* 765, 767, 769, 772, 774, 781, 12 Feb. 1949 (C, F); *Madsen, Wagner & Pates* 2045, 2046, 2058, 2066, 2070, 15 Apr. 1950 (C, F); *M. H. Voth* 10-13, 4 Nov. 1950 (C, F); *J. Harmon* 28, 607, 608, 4 Nov. 1950 (C, F); *A. H. Johnston* 42, 44, 45, 48, 50, 53, 68, 69, 4 Nov. 1950 (C, F); LEE CO.: on dry sand in region of Hendry Creek, about 10 miles south of Fort Myers, *P. C. Standley* 73231, 11-25 Mar. 1940 (C). MONROE CO.: on rocks at low water mark, *Marshall A. Howe* 1635, 7 Nov. 1902 (C). SARASOTA CO.: south of Venice, *P. C. Standley* 92780, 9 Mar. 1946 (C). WAKULLA CO.: sulphur spgs., ½ mile north of Newport, *Drouet, Crowson & Thornton* 11347, 25 Jan. 1949 (C, F); *Nielsen, Madsen & Crowson* 765, 767, 769, 772, 774, 781, 12 Feb. 1949 (C, F); *J. Harmon* 27, 10 Nov. 1950 (C, F).

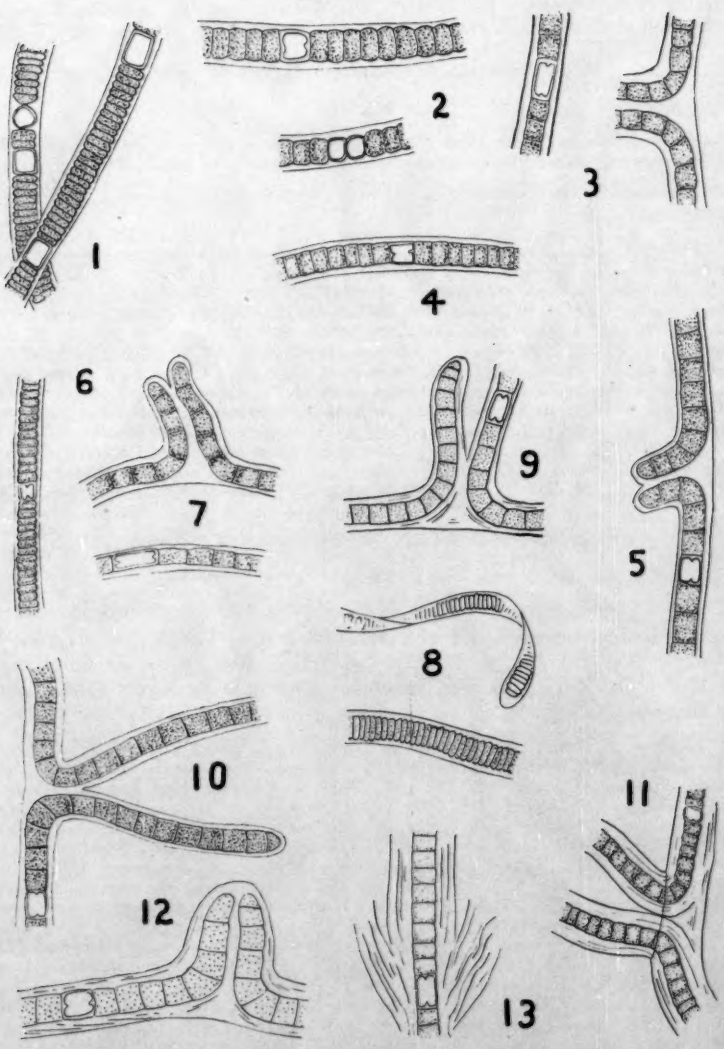
12. SCYTONEMA CRUSTACEUM Bornet & Flahault

Fig. 12

Filament width varied from 15 to 18.5μ; trichome diameters averaged 7μ.

The specimens were found with *Microcoleus* spp., *Coccochloris stagnina f. rupestris* (Lyngb.) Dr. & Daily, *Anacystis* spp. and *Stigonema panniforme* B. & F. The species has been reported for the state by Wolle (1887) and by Brannon (1952).

FLORIDA: *J. Donnell Smith*, Mar. 1878 (P, N). ALACHUA CO.: *H. W. Ravenel*, type of *S. mirabile* Wolle (P), isotype (H). CITRUS CO.: Lake Tsala Apopka, Hernando, *Brannon* 85, Aug. 1942 (C, U). DADE CO.: quarry, 19th Ave. & 79th St., N.W. Miami, *Ruth Patrick*, Jan. 1939 (C). LEE CO.: on bark, moist open sand, on log, in region of Hendry Creek, about 10 miles south of Fort Myers, *P. C. Standley* 73207, 73367, 73369, 11-25 Mar. 1940 (C); south of Estero, *P. C. Standley* 92781, 15 Mar. 1946 (C); between Estero and Bonita Spgs., *J. A. Steyermark* 63199a, 10 Mar. 1946 (C). LEON CO.: 15 miles west of Tallahassee, Fla. Highway 20, *Nielsen, Madsen & Crowson* 796, 22 Jan. 1949 (C, F). MONROE CO.: appressed to marl, marl flats east of rd. leading south from inn, Big Pine Key, *E. P. Killip* 40657, 3 Nov. 1950 (C, N); button-wood swamp in palm-pine woods N.W. of inn, on moist black mud, Big Pine Key, *E. P. Killip* 41685, 9 Jan. 1952 (C, N); brown, moist soil on drying pool near rd. above S. R. D. Camp, Big Pine Key, *E. P. Killip* 41760, 17 Jan. 1952 (C, N); dark green, on saline flats back of inn, Big Pine Key, *E. P. Killip* 41805, 22 Jan. 1952 (C, N); dark green, *Lobelia* bog along rd. to Watson Hammock, Big Pine Key, *E. P. Killip* 41822, 25 Jan. 1952 (C, N); grayish black, saline flats at Shell Beach, Big Pine Key, *E. P. Killip* 41822, 25 Jan. 1952 (C, N); grayish black, saline flats at Shell Beach, Big Pine Key, *E. P. Killip* 41856, 31 Jan. 1952 (C, N); marshy places, stunted button-wood stand west of artificial lake, Big Pine Key, *E. P. Killip* 41908, 41910, 41912, 9 Feb. 1952 (C, N). SANTA ROSA CO.: in depression in sand dunes east of Pensacola Beach, *Drouet, Nielsen, Madsen, Crowson & Pates* 10594, 10598, 10603, 8 Jan. 1949 (C, F). WAKULLA CO.: on bark of *Ostrya virginiana*, sulphur spgs. near Newport, *Nielsen*, 23 July 1952 (C, F).



Figs. 1-13.—1. *Scytonema cincinnatum* B. & F. X300; 2. *S. coactile* B. & F. X300; 3. *S. guyanense* B. & F. X300; 4. *S. stuposum* B. & F. X300; 5. *S. javanicum* B. & F. X375; 6. *S. varium* B. & F. X650; 7. *S. Hofmannii* B. & F. X450; 8. *S. ocellatum* B. and F. X450; 9. *S. tolypotrichoides* B. & F. X450; 10. *S. figuratum* B. & F. X300; 11. *S. Myochrous* B. & F. X200; 12. *S. crustaceum* B. & F. X450; 13. *S. crassum* B. & F. X275.

Scytonema Wolleanum De Toni as reported for the state by Tilden (1910) has been referred to *S. crustaceum* B. & F. (Drouet, 1939).

13. SCYTONEMA CRASSUM Bornet & Flahault

Fig. 13

Filament width averaged about 37μ; trichome diameters were approximately 15μ.

BROWARD CO.: on barren ground near east end of Hollywood blvd., Hollywood, *Drouet & Louderback*, 27 Dec. 1948 (C, F).

REFERENCES

BORNET, ED., AND FLAHAULT, CH. 1868-88—Revision des Nostocacés Hétérocystées Continues dans les Principaux Herbiers de France. Ann. Sci. nat., VII^e Sér., Bot., III, IV, V, and VII.

BRANNON, MELVIN A. 1945—Factors affecting the growth of Myxophyceae in Florida. Quart. J. Fla. Acad. Sci. 8(4):296-303.

——— 1952—Some Myxophyceae in Florida. Ibid. 15(2):70-78.

CROWSON, DOROTHY E. 1950—The algae of a modified brackish pool. Fla. State Univ. Studies 1:1-32.

DROUET, FRANCIS 1939—Francis Wolle's filamentous Myxophyceae. Field Mus. Nat. Hist. Bot. Series 20(2):17-64.

NIELSEN, C. S., AND GRACE C. MADSEN 1948a—Preliminary check list of the algae of the Tallahassee area. Quart. J. Fla. Acad. Sci. 11(2-3):63-66.

——— 1948b—Check list of the algae of northern Florida I. 11(4):111-117.

——— AND ——— 1956—Florida Scytonemataceae I. Amer. Midl. Nat. 55:194-198.

TAYLOR, WILLIAM RANDOLPH 1928—Marine algae of Florida with special reference to the Dry Tortugas. Papers from the Tortugas Laboratory (Carnegie Institution of Wash.) 25:1-219.

TILDEN, JOSEPHINE 1910—Minnesota Algae, Vol. I, Bot. ser. VIII, Minneapolis, Minn.

WOLLE, FRANCIS 1877—Fresh Water Algae of the United States. Bethlehem, Pa.

The Mass Culture of a Presumably Autotrophic Dinoflagellate

M. J. Delany[1,2]
University of Florida, Gainesville

The dinoflagellates are a group of microorganisms found commonly, but not exclusively, in samples of marine plankton. The number of their individuals and species varies considerably in both space and time, and relatively few studies have been made up to the present on the causes underlying such fluctuations. Observations on their nutritional requirements as deduced from laboratory culture, are believed to have an important bearing on these aspects. Unfortunately, little thorough work has been undertaken in this field. Sweeney (1951) provided a comprehensive resumé of the laboratory culture of marine dinoflagellates as well as a valuable contribution on the factors stimulating the population growth of pure cultures of *Gymnodinium splendens*. A number of other species have also been grown in laboratory culture (Barker, 1935; Braarud, 1945; King, 1950) but to the author's knowledge the successful mass culture of *Amphidinium* has not been previously attained.

Amphidinium ovoideum Lemmermann was used exclusively throughout this study. First observed in this laboratory in October, 1953, it was subsequently obtained in a number of samples from the Florida Gulf coast. It is one of the smaller more easily recognizable species of this genus of naked dinoflagellates. The size of the organism was generally slightly smaller than that suggested by Kofoid and Swezy (1921) who claimed its length to vary between 17μ and 23μ. Although a number of individuals were found to fall within these limits, more frequently their length was of the order of 12μ to 15μ. Apart from this wider size range (12μ to 23μ) the organism compared favorably with the description of these authors.

Blooming, or the incidence of organisms of a single species in numbers large enough to discolor expanses of water, is a characteristic of numerous species of dinoflagellates (Darwin, species unknown, 1839; Nightingale, *Gymnodinium* and *Gonyaulax*, 1936; Martin and Nelson, *Amphidinium*, 1929; Davis, *Gymnodinium*, 1948). Certain blooms are of economic importance as they are believed to be the causative agents of mass mortality of fish and other marine organisms. The periodic heavy death of fish off the west Florida coast has been correlated with outbreaks of blooms caused by the dinoflagellate *Gymnodinium brevis* (Gunter, *et al.*, 1948), while a species of *Gonyaulax* had a similar effect off Galveston, Texas (Connell and Cross, 1950). A method has been devised for the laboratory culture of *Amphidinium ovoideum* in bloom proportions and it is the aim of this paper to describe how this

[1] Fulbright Fellow.

[2] Present address: Department of Zoology, University of Glasgow, Scotland.

has been achieved and to discuss briefly its relation to the blooming phenomenon under natural and alternative laboratory conditions.

PRELIMINARY EXPERIMENTS

In this study *Amphidinium ovoideum* first became available for laboratory experiments in October, 1953, when it was observed growing well in a mixed culture of marine microorganisms. The original stock had been collected in the vicinity of Sarasota on the Florida Gulf coast. Inoculation of a sea water medium (no record was kept of its composition) had subsequently taken place.

A few drops of this mixed culture were added to media of the types prepared by Rice (1953) and Barker (1935). *Amphidinium* reproduced steadily in Rice's medium and as a result no further use was made of Barker's medium. In further subculturing, a drop of a culture, selected for its numerically high concentration of *Amphidinium*, was added to the newly prepared solution. As a medium capable of supporting rich populations of the organism was now available, further experiments centered around establishing whether or not *Amphidinium* had a highly specific inorganic nutrient requirement. To determine this, nineteen variants of Rice's medium were prepared, each differing from the original only in respect of one of its chemical components. For these experiments 250 ml Erlenmeyer flasks stoppered with cotton and containing 100 ml of solution were selected. Examination at 7-21 day intervals lasted over a total period of 90 days within which time it was possible to assay the general trends the cultures were following. All the populations attained a maximum approximately 40 days after initiation.

Throughout this study one method of estimating population density has been applied. Basically similar to that described by Lackey (1938) it involves a direct count of the organisms within a known quantity of medium. To measure this quantity the pipette delivering the drop onto the slide must be calibrated in drops served per milliliter. It is also essential to determine the proportion of the total field covered by a single microscopic path traversing the cover slip. Four paths, one transverse and three longitudinal, were crossed in making each estimate. In all cases this was undertaken under the 10X ocular and 10X objective lenses and when using a 25 X 25 mm cover slip this represented very close to one quarter the total volume of fluid beneath the cover slip. Thus by multiplying the number of drops the pipette served per milliliter by four times the number of organisms counted within the four paths, an absolute estimate of the population per milliliter became available. Care had to be taken to prevent overflow of liquid along the edges of the cover slip. It was found advisable when making counts of high populations of *Amphidinium* to use a pipette with a narrow opening and hence producing smaller drops, than to attempt dilution of the sample.

The flasks were placed on a shelf beside a north facing window and with a two filament 40 watt "cool white" fluorescent tubing lamp situated approximately 30 inches above the cultures. The lamp provided illumination 24 hours per day. Control of temperature was not practicable and over the total period of experiment varied between 18° and 35° C.

The composition of the different media and the concentrations at which they produced maximum populations are displayed in table 1.

TABLE 1.—The proportions of chemicals used in the preliminary experiments and the concentrations producing the maximum populations.

Chemical Compound	Range in ppm	Salt conc. producing max. growth	Pop./ml at max. growth (,000s)
KNO_3	1, 40, 75, 100,* 250, 500	250	535
$CaCl_2$	1, 5, 20,* 50, 100	100	610
$MgSO_4$	1, 10, 20,* 50, 100	20	420
$Fe(NH_4)(SO_4)2$	0, 5*	5	420
KH_2PO_4	0, 5, 8,* 25, 50	8	420

* Rice's standard medium. Variations from this medium were only made with respect to one of the above chemical compounds at a time. Thus six solutions were prepared differing from one another with respect to their KNO_3 content (these varied from 1 ppm to 500 ppm as shown in column 2) but otherwise retaining the proportions as occurred in Rice's standard medium. Variations in the proportions of the other chemicals are shown in column 2.

Discoloration of the cultures occurred in a number of instances but as contamination with other microorganisms was known to occur, responsibility for this discoloration could not be ascribed with certainty to *Amphidinium*. These experiments do not suggest the organism to have a high specificity to any single chemical radical but as a general rule it appeared to grow with greater vigor in the higher chemical concentrations. Low concentrations of inorganic nutrients did not prevent growth but failed to support populations exceeding 100,000 individuals per milliliter. This was subsequently confirmed when attempts were made to cultivate *Amphidinium* in filtered sea water (which had previously been maintained in darkness 6-8 weeks) autoclaved at 120° C and 17 lbs./sq. in. for 30 mins. and to which no nutrient was added. The organism attained a maximum population of 99,900 individuals per milliliter in one of the four Erlenmeyer flasks so treated. Substantial growths occurred in the other three but at a somewhat lower maximum density, in the range of 50,000 to 60,000 individuals per milliliter.

FINAL EXPERIMENTS

The preliminary experiments provided a general indication of the nutritional requirements of *Amphidinium*. It was following a consideration of these data that a new medium was synthesized. The following chemicals were added, in the proportions stated, to aged filtered sea water: KNO_3—25 ppm; $CaCl_2$—100 ppm; $MgSO_4$—75 ppm; KH_2PO_4—50 ppm, and $Fe(NH_4)(SO_4)2$—5 ppm. The proportions of these chemicals do not invariably coincide with those that might be anticipated from table 1. The presentation of the data in this table is empirical and makes no allowance for such factors as the extent within a given period of time a population may remain in close proximity to, or digress from, its maximum. The determi-

nation of the relative amounts of each chemical to be included was made only after reference to the original figures and hence allowed for contingencies of this type.

Three 125 ml Erlenmeyer flasks each containing 50 ml of this medium were autoclaved for 30 mins. at 121° C and 15 lbs./sq. in. On removal from the autoclave a faint, white precipitate was present. The sea water was taken at Cedar Key, Florida, and kept in darkness for 6-8 weeks prior to use. As a basis for the comparison of growth rates, three flasks of sea water without added nutrients were similarly treated. All the Erlenmeyer flasks were new and rinsed thoroughly in distilled water before adding the sea water and nutrients. Temperature and lighting conditions did not differ from those in the preliminary experiments.

The previous method of inoculation could not guarantee the isolation of *Amphidinium* from other microorganisms and to facilitate this an alternative more refined technique was devised. It consisted of resting a small sterile portion of cover slip on a glass slide which was then placed on the microscope stage. A micropipette delivered a drop of a medium containing *Amphidinium* onto the portion of cover slip. Should a drop after microscopic examination contain any organism other than *Amphidinium* it was discarded and the operation repeated until only that dinoflagellate was present. Following an estimation of the number of organisms in a drop, the cover slip was transferred to one of the sterile media. Rapid examination and the use of small drops from a culture containing large numbers of the organism to be isolated are recommended for the successful operation of this technique.

Population estimates were made every 3 to 9 days, once measurable growth had started, for a total period of 96 days. To minimize contamination from bacteria and other microorganisms the pipette used throughout

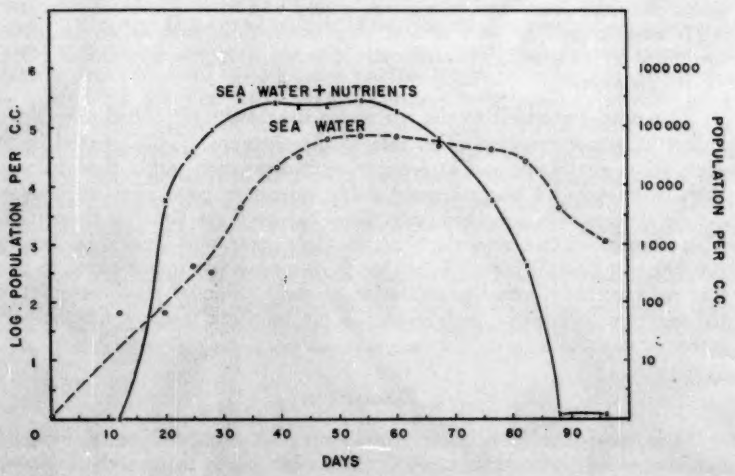


Figure 1

TABLE 2.—The growth of *Amphidinium* in the two sets of cultures.

Time (days)	Population/milliliter	
	Sea water	Sea water plus nutrients
0 (Inoculation)	0.8	0.84
12	67	....
20	67	6,800
25	433	43,667
28	320	91,880
33	4,720	293,200
39	22,760	259,320
43	33,120	240,200
48	66,600	232,320
54	73,160	293,040
60	69,813	178,513
67	61,320	67,527
76	40,853	5,547
82	29,760	480
88	4,213	....
96	1,170	....

the sampling period was sterilized before insertion into each flask. In summarizing the data (table 2, fig. 1) the mean population figures for each of the two series of flasks have been given.

For the first 60 days of experiment no protistan other than *Amphidinium* was observed in any of the cultures. Compared to the 48,000 *Amphidinium* actually counted over the same period, the role of extraneous organisms, if present, would appear to be insignificant. After this time small non-motile green and blue-green algae were seen rarely and it is concluded that even when other organisms were present they occurred in such relatively minute quantities as to exercise virtually no influence over the population growth of *Amphidinium*.

The nutrients added to the sea water apparently stimulated, directly or indirectly, a more rapid division rate of the organism. This resulted in the assumption of a higher and earlier maximum population within these cultures. Both cultures had a comparatively stable maximum population for approximately 30 days with a marked green discoloration of the liquid in those flasks. This disappeared soon after the phase of stable population density, i.e. between 200,000 and 300,000 per milliliter, had been passed. It is interesting to note that an apparently complete utilization of the nutritional requirement(s) of the organism takes place more rapidly in the sea water medium supplied with inorganic chemicals.

DISCUSSION

It is concluded from these experiments that the addition of inorganic nutrients to sea water stimulates a significant increase in the growth of *Amphidinium*. Unfortunately, with the facilities available it was not possible to

control experimental conditions as rigidly as might be desired. Nevertheless, apart from the addition to one of inorganic nutrients, two series of flasks were treated in precisely the same manner and any difference their *Amphidinium* populations displayed, must be attributed, in some way, to the added materials. That these organisms have no organic nutrient requirements has received confirmation by Odum, *et al.* (1954). These workers by adding charcoal particles to thriving *Amphidinium* cultures made unavailable the estimated 3.2 ppm organic content. No decline in the growth of the cultures resulted. By virtue of its apparently autotrophic habit, the organism affords an interesting comparison with other studies on the nutritional requirements of dinoflagellates. Sweeney (1951) found soil extract to be an essential component of cultures of *Gymnodinium splendens* while Barker (1935) found the same true of *Prorocentrum gracile, P. micans* and *Peridinium* sp.

It is difficult to state positively whether a medium has been found in which *Amphidinium* can be grown to its maximum capacity. Only further research would determine its growth rate in modified physical conditions and higher concentrations of inorganic compounds. Furthermore, no attempt has been made to culture *Amphidinium* in a medium supplied with vitamins or other organic matter. Although these suggestions would undoubtedly provide further interesting information on the nutritional requirements of this organism the major aim, namely its cultivation in bloom proportions, has been achieved. Evidently *Amphidinium* is rather slow in reaching its level of stable population (30 to 40 days) and acceleration of this phase might prove practicable.

The reasons underlying the outbreak of blooms of marine dinoflagellates are not well established. Analysis of the data on the laboratory culture of *Amphidinium* has, it is believed, three significant aspects—the accomplishment of a relatively early maximum, an appreciably higher population here than in the control and a relatively early decline and apparently complete disappearance. This latter factor is of interest as in a variety of other cultures containing lesser amounts of nutrients the organism has survived at a low population density over periods of up to 7 or 8 months. It is tentatively suggested that as a result of the growth-promoting substances being available in large quantities an initial period of rapid growth takes place. A combination of this and an allelocatalytic affect results in a higher maximum than would prevail were the latter influence absent. The equilibrium involves a balance between available nutrients and allelocatalysis. However, as the organism is basically dependent upon the available nutrients their extraordinarily rapid utilization, due primarily to the allelocatalytic effect, results in their premature and complete utilization. This is purely speculative and requires confirmation.

Acknowledgment.—The author is indebted to Dr. J. B. Lackey for his constant advice and encouragement throughout this work, which was done at the Sanitary Research Laboratory of the Florida Engineering and Industrial Experiment Station.

SUMMARY

A medium composed of sea water and inorganic nutrients capable of supporting blooms of *Amphidinium ovoideum* Lemm. has been described. The growth of populations in this medium has been compared against that in

autoclaved sea water without the addition of nutrients. The former supported a maximum population approximately four times as high as the latter. The reasons for this have been attributed, directly or indirectly, to the inorganic nutrients. Possible factors in the productions of blooms have been briefly discussed.

REFERENCES

BARKER, H. A. 1935—The culture and physiology of the marine dinoflagellates. Arch. Mikrobiol. 6:157-181.

BRAARUD, T. 1945—Morphological observations on marine dinoflagellate cultures. Der Norske Videnskups Akademi i Oslo I. Mat. Naturu. Klasse. No. 11.

CONNELL, C. H. AND J. B. CROSS 1950—Mass mortality of fish associated with the protozoan *Gonyaulax* in the Gulf of Mexico. Science, 112:359-363.

DARWIN, C. 1839—Journal of researches into the natural history and geology of the countries visited during the voyage of H.M.S. Beagle round the world. London.

DAVIS, C. C. 1948—*Gymnodinium brevis* sp. nov., a cause of discolored water and animal mortality in the Gulf of Mexico. Bot. Gaz. 109:358-360.

GUNTER, G., R. H. WILLIAMS, C. C. DAVIS AND F. G. W. SMITH 1948—Catastrophic mass mortality of marine organisms and coincident phytoplankton bloom on the west coast of Florida, November, 1946, to August, 1947. Ecol. Monogr. 18:309-324.

KING, G. S. 1950—Production of red tide in the laboratory. Proc. Gulf and Caribbean Fisheries Inst. 2nd Ann. Session 1949, 107-109.

KOFOID, C. A. AND D. SWEZY 1921—The free-living unarmored Dinoflagellata. University of California Press, Berkeley.

LACKEY, J. B. 1938—The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. Pub. Health Rep. 53:2080-2093.

MARTIN, G. W. AND T. C. NELSON 1929—Swarming of dinoflagellates in Delaware Bay, New Jersey. Bot. Gaz. 88:218-224.

NIGHTINGALE, H. W. 1936—Red water organisms. Their occurrence and influence upon marine aquatic animals, with special reference to shellfish in waters of the Pacific Coast. Washington.

ODUM, H. T., J. A. HYNES AND J. V. SLATER 1954—Suggestions concerning the use of charcoal for control of "red tide" blooms. In preparation.

RICE, T. R. 1953—Phosphorus exchange in marine phytoplankton. U. S. Fish and Wildlife Service. Fishery Bulletin 54(80):75-89.

SWEENEY, B. M. 1951—Culture of the dinoflagellate *Gymnodinium* with soil extract. Amer. J. Bot. 38:669-677.

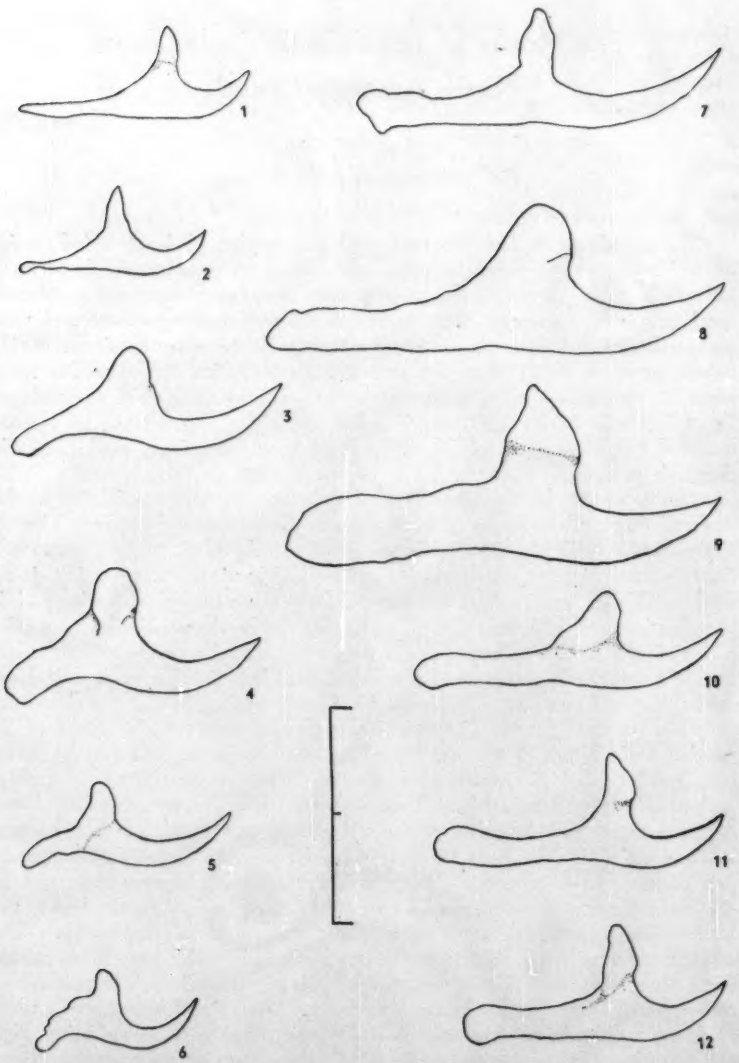
The Hooks of Taenioid Cestodes from North American Felids

Nathan W. Riser
Fisk University, Nashville, Tennessee

The cestode genus *Taenia* is composed of a number of closely allied species of which many are poorly defined and many are consistently improperly identified. Since most of the descriptions have been based on contracted specimens or upon worms that have been flattened under pressure and thus are markedly distorted (an extreme example is the type specimen of *T. balaniceps* Hall, 1910), there are very few species which can be readily identified on the basis of size, shape of the strobilus, or proglottid morphology. In addition, the hooks borne on the scolex, have been measured under various unstated conditions, and on the whole, have been surprisingly inadequate for diagnosing species.

The literature dealing with *Taenia,* indicates very great variability in the size and shape of the hooks of most species. Stevenson and Engberg (1904) analyzed the variability in *Taenia pisiformis* Bloch, 1780, and demonstrated that the hooks in that species varied in size and shape even on an individual scolex. Similar studies have not been undertaken with other species and it is rather interesting to note that *T. pisiformis* can be characterized as a species in which the hook size and shape does vary, although specimens from California, Utah, Pennsylvania and Tennessee examined in this study had large hooks 0.25-0.27 mm long. Other species do not seem to show as great extremes as those reported for *T. pisiformis* although the shape of the hooks of *T. taeniaeformis* Batsch, 1786, does show a marked variation, and yet the literature indicates that size variation is the rule. As stated above, the various authors who have reported hook sizes have not used constant methods. Some have measured hooks attached to the scolex, and have measured them *en face* or from the side; other workers have isolated the hooks and oriented them in one plane. These methods do not yield the same measurements, and in the main account for compilations of data resulting in keys in which the hook measurements, show a wide range, and overlap consistently. The measurements, and the illustrations in this paper were made from hooks teased from dissociated scoleces and mounted in poly-vinyl-alcohol. The method of measurement is that of Stevenson and Enberg (1904) and is commonly used. It is very difficult to orientate hooks in one plane even when using high magnification (144 diameters) with a binocular dissecting microscope. Many hooks roll or move after the coverslip is applied and thus the preparations used in this study seldom showed more than twenty percent properly orientated. All measurements were made, using a camera lucida, on a scale projected from a stage micrometer.

The two, heavy-bodied species of *Taenia* from cats can sometimes be distinguished on strobilar characteristics. *Taenia omissa* Lühe, 1910, apparently



Figs. 1-12.—Commonly encountered hook shapes.—All figures drawn with the aid of a camera lucida. The scale is equal to 0.20 mm. Figs. 1-6 small hooks; figs. 7-12 large hooks. Figs. 1 & 11 *Taenia omissa*. 2 & 12 *Taenia rileyi*. 3 & 9 *Taenia taeniaeformis*. 4 & 8 *Taenia laticollis*. 5 & 7 *Taenia macrocystis*. 6 & 10 *Taenia pisiformis*.

a common parasite of the mountain lion, frequently has proglottids which are short and very broad and such a strobilus could not easily be mistaken for *T. taeniaeformis*. However, some specimens are very similar to *T. taeniaeformis* in proglottid size and shape. The hooks of the two species are markedly different (figs 1, 3, 9, 11) and can not be confused. The hooks (figs. 1, 11) of *T. omissa* were obtained from specimens of *Felis concolor* collected by Dr. J. M. Linsdale in Monterey Co., California. Cysticerci of this worm were obtained from *Odocoileus hemionus* in California. Skinker (1935) described *Taenia lyncis*, however, her description was based on two different species, one being *T. omissa*. Some of the specimens of *T. omissa* in the U. S. Nat. Mus. Helm. collection have been examined, No. 26343 from *Felis azteca*, No. 26884 from *Felis oregonensis*, Nos. 26884, 39878, 39883, from *Felis hippolestes*, and No. 39880 from *Odocoileus virginianus*. Slides No. 26718, labeled *T. lyncis*, contain portions of *T. omissa*, hooks of *T. omissa* and hooks of an undetermined species of *Taenia*.

Taenia lyncis of Skinker is a composite species. The description was taken from specimens of *T. omissa* and *T. rilevi* Loewen, 1929. The situation is further confused by the fact that Loewen's description of *T. rilevi* is also a composite, the scolex being that of *T. laticollis* Rud., 1819, and only the strobila being new. (I am forced to wonder if some of the scoleces might not also have been *T. macrocystis* Diesing, 1850). Loewen's material consisted of strobilae without scoleces, and scoleces without proglottids. Adult *T. rileyi* were collected from *Lynx rufus baileyi* in Skull Valley, Utah and adults from *L. rufus* were collected by Dr. Linsdale in Monterey Co., California. Dr. A. W. Grundmann has generously loaned me two of the slides reported as *T. rileyi* by Butler and Grundmann (1954) and these were specimens of *T. macrocystis*. Cysticerci of *T. rileyi* from *Peromyscus* from California, and from *P. maniculatus nubriterrae* (USNMHelm. Col. No. 39871) were examined.

T. omissa may be characterized by its large size (up to 60 cm in length, 12 mm in breadth, and 2. mm in thickness). The unsegmented zone of growth is very short. The vagina follows a wavy course much like that of *T. bubesei* Ortlepp. The large hooks (fig. 11) are 0.24-0.28 mm long (Lühe, 1910, reported 0.27-0.29 mm). Most of the North American specimens which were examined had large hooks 0.24-0.25 mm long. Using Stevenson's (1904, fig. 9) plan of measurements, the handle (Stevenson's character b) is 0.17-0.19 mm long. The blade length (character c) is 0.11 mm. The small hooks (fig. 1) are characteristic for the species. They are 0.18-0.21 mm long, mostly 0.19-0.20 mm. The handle is 0.12-0.13 mm and the blade is 0.09-0.10 mm.

T. rilevi has a strobilar configuration much like that of *T. pisiformis*. The large hooks (fig. 12) are 0.22-0.24 mm long with the handle 0.17-0.18 mm and the blade 0.10-0.11 mm. The small hooks (fig. 2) are 0.16-0.17 mm long with the handle 0.11 mm and the blade 0.07 mm. In profile, the guard tends to broaden out at its base producing a triangular appearance.

T. laticollis and *T. macrocystis* are rather small, slender, members of the genus. They both were commonly found in the Lynx in the Rocky Mountains, frequently associated with *T. rileyi*. (A road-kill bobcat was examined by Dr. N. A. Meinkoth at Jackson Hole, Wyoming, and the *Taenia* present which were forwarded to me were all *macrocystis*). Even in contracted specimens many of the posterior proglottids are 2-3 times as long as broad. The genital atrium of *T. macrocystis* is large and sucker-like and in mature and gravid proglottids is distinctly cut-off from the surrounding tissues. The hooks of the two species are quite distinctive. The peculiar alternate setting of one hook further toward the center of the rostellum in *T. macrocystis* is characteristic. The large hooks (fig. 7) in this species have a characteristically nobby handle which frequently is notched. The small hook (fig. 5) has a long slender blade, the guard is not much wider than the rest of the hook *en face*, and is approximately the same width at top and bottom. The large hook of *T. laticollis* is heavy and as other workers have pointed out, is quite similar to that of *T. taeniaeformis* except that the shape of the guard in the two species is not similar. The small hooks however, are quite distinctive, being very solid, and with the guard much wider at its base, *en face*, and, in that respect, resembling a shepherds purse. Skinker (1935) stated that the guard was "only slightly bifid." Dollfus (1938) repeated this statement pointing out that this was not the case in *T. taeniaeformis* as had been reported, and, in actuality, a bilobed appearance is only indicated in profile as a result of the flared end of the guard of *T. laticollis*.

	Total Length mm	Handle (b) mm	Blade (c) mm
T. taeniaeformis			
Large	0.38-0.40	0.26	0.18-0.19
Small	0.25-0.26	0.14-0.16	0.14-0.15
T. laticollis			
Large	0.38-0.40	0.26-0.29	0.17
Small	0.21	0.14	0.14
T. macrocystis			
Large	0.32-0.34	0.17-0.18	0.16
Small	0.19	0.09-0.10	0.12-0.13
T. pisiformis (According to Stevenson 1904)			
Large	0.24-0.29	0.14-0.20	0.09-0.13
Small	0.13-0.17	0.08-0.11	0.06-0.10
(Present study including adults and cysticerci)			
Large	0.25-0.27	0.16-0.17	0.09-0.10
Small	0.14-0.15	0.09-0.10	0.08-0.09
T. omissa			
Large	0.24-0.28	0.17-0.19	0.11
Small	0.18-0.21	0.12-0.13	0.09-0.10
T. rileyi			
Large	0.22-0.24	0.17-0.18	0.10-0.11
Small	0.16-0.17	0.11	0.07

The six species of *Taenia* which are commonly encountered in North American felids can be divided into two groups on the basis of the large hooks. *T. taeniaeformis, T. laticollis,* and *T. macrocystis* have large hooks over 300 mu in length. These hooks, however, differ considerably in shape. The large hooks of *T. omissa, T. pisiformis,* and *T. rileyi* are very similar both in size and in shape. It is the size and shape of the small hooks which is of most value in distinguishing the species of both groups.

Taenia ovis Cobbold, 1860, was reported from *Puma concolor* by Dollfus in 1944, but has not been encountered in the present survey of North American felids. The hooks of this species are smaller than those of the species which have been discussed.

The following chart shows the range of hook-sizes which were encountered for the various species, but does not include developing hooks. The latter condition was noticed primarily in the case of the small hooks of *T. laticollis* where the developing hooks were practically handle-less.

REFERENCES

BUTLER, J. N. AND A. W. GRUNDMANN 1954—The intestinal helminths of the coyote *Canis latrans* Say, in Utah. J. Parasit. 40:440-443.

DOLLFUS, R. PH. 1938—Sur un *Cysticercus fasciolaris* Rudolphi teratologique (polycephale). Ann. Parasitol., 16:133-141.

——— 1944—Sur les Cestodes de *Puma concolor* (L.). Bull. Mus. Nat. Hist. Nat., Paris, ser. 2 16:316-320.

HALL, M. C. 1910—A new species of cestode parasite (*Taenia balaniceps*) of the dog and of the lynx, with a note on *Proteocephalus punicus*. Proc. U. S. Nat. Mus. 39:139-151.

LOEWEN, S. L. 1929—A new cestode, *Taenia rileyi* n. sp., from a lynx. Parasitology 21:469-471.

LÜHE, M. 1910—Cystotänien südamerikanischer Feliden. Zool. Jahrb. (Suppl. 12) 3:687-710.

ORTLEPP, R. J. 1938—South African helminths. Part II. Some Taenias from large wild carnivores. Onderstepoort J. Vet. Sc. Animal Indust., 10:253-278.

SKINKER, MARY S. 1935—Two new species of tapeworms from carnivores and a redescription of *Taenia laticollis* Rudolphi, 1819. Proc. U. S. Nat. Mus. 83:211-220.

STEVENSON, E. C. AND C. C. ENGBERG 1904—Variation in the hooks of the dog-tapeworms *Taenia serrata* and *Taenia serialis* with a discussion of the mathematical results. Studies Zool. Lab. Univ. Nebr. (59):409-448.

Observations on the Life Histories and the Distribution of the Xanthidae (Mud Crabs) of Chesapeake Bay[1]

Edward Parsons Ryan
Department of Zoology and Entomology
University of Hawaii, Honolulu

The life histories and distribution of many animals which inhabit estuaries are well-known, but some, of direct or indirect economic importance, have been studied very little. This is true of a large number of inconspicuous or seemingly unimportant species. Although investigations have been made of the Xanthidae, a family commonly known as mud crabs, research into the ecological aspects has not been fully explored for a number of species.

The objective of this investigation was to increase knowledge of the life histories and distribution of the five species of this family which inhabit the Chesapeake Bay. A sixth species has been reported both north and south of Chesapeake Bay and is discussed since possibly it may be found in the Bay.

Many of the papers concerning the xanthids are principally taxonomic descriptions or contain records of collections in specific areas. The late Dr. Mary Jane Rathbun was a leading authority of the crabs of the world, and her paper (Rathbun, 1930) on the cancroid crabs of America, is of great fundamental value for its treatment of the taxonomy and distribution of the group in question. A number of authoritative studies of the mud crabs in regions other than Chesapeake Bay are useful in the critical review of these animals in our waters. Hay and Shore (1918) discussed the xanthids in their report on the decapods of the region of Beaufort, North Carolina, Lunz (1937) described the xanthids of the Carolinas, and Fowler (1911) assembled records of the mud crabs of New Jersey.

Important contributions to the knowledge of the early development of mud crabs have been made by Birge (1883) who described the larval stages of *Neopanope texana sayi* (Smith), formerly *Panopeus sayi* Smith, from collections made in Chesapeake Bay at Crisfield, Maryland, and by O. W. Hyman (1925) who studied the larval stages of other species of this family.

The literature available in this field includes the reports of two biological surveys which discuss xanthids and the factors affecting their distribution. Cowles (1930) published the results of a United States Bureau of Fisheries survey of the offshore waters of the Chesapeake Bay for the years 1916-1922. This is the first important account of the mud crabs of Chesapeake Bay.

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[1] The data and certain portions of this paper were submitted in thesis form as partial fulfillment of the degree of Master of Science, University of Delaware, June, 1951. Contribution No. 104 of the Chesapeake Biological Laboratory, Maryland Department of Research and Education, Solomons, Maryland, and No. 2 of the Marine Laboratories, University of Delaware, Newark, Delaware.

Most of the stations visited during the present investigation were located on the inshore waters of the Bay. The two investigations supplement each other to yield a satisfactory analysis of many parts of the Bay and its tributaries. Sumner, Osburn and Cole (1911) recorded the results of a biological survey of the Woods Hole region which includes several xanthids. Truitt (1945, 1947) has briefly summarized progress in the survey of mud crabs of Chesapeake Bay in the Annual Reports of the Maryland Department of Research and Education. Much of the material upon which his comments are based has been incorporated in this study. Ferguson and Jones (1949) recorded three species from the mouth of Chesapeake Bay.

The Xanthidae may be of economic importance to the shellfish industry. Kudo (1939) and Prytherch (1940) have shown that the mud crabs may act as alternate hosts of the gregarine parasite, *Nematopsis legeri* (de Beauchamp), of the oyster. They have shown that certain stages of the parasite may develop in the gut of the crab. According to Engle (1946), there is no relation between the intensity of this parasite and poor condition or mortality of the oysters. Perhaps, in times of stress, owing to other factors, *Nematopsis* may have a visibly detrimental effect. Carriker (1951) cited the work of Rutgers University zoologists which indicates that mud crabs may feed extensively on the young of the hard clam, *Venus mercenaria* Linnaeus. Landers (1954) believes that *Neopanope texana* is a menace to clams, particularly to those less than 10 mm in length. McDermott and Flower (1952) described the ecological relationships of mud crabs on oyster beds in Delaware Bay. Several experiments have indicated that the "large mud crabs" are selective in their feeding on oysters, particularly the small thinner-shelled individuals, under laboratory conditions. They theorize that mud crabs may contribute to a portion of the overall oyster mortality on the New Jersey beds in Delaware Bay, but not much conclusive evidence is available on this matter.

Acknowledgments.—Grateful appreciation is expressed for the help of the following persons, in addition to those thus far cited, in bringing this paper to completion: L. Eugene Cronin, University of Delaware Marine Laboratory, for much help, criticism, and inspiration; R. V. Truitt, Director of the Chesapeake Biological Laboratory, for providing laboratory facilities and helpful suggestions; G. F. Beaven, Maryland Department of Research and Education, for the arrangement of collecting trips; Romeo Mansueti, Department of Research and Education, for technical and editorial aid and the illustrations; J. D. Andrews, Virginia Fisheries Laboratory, for collections from the lower Bay; Mrs. Helen L. Hayes, U. S. Fish and Wildlife Service, for collections from many regions of the Bay, and Dr. Ralph Buchsbaum, University of Pittsburgh, through whose arrangement the photographs were made.

METHODS OF COLLECTION AND OBSERVATION

The collections examined in the course of this investigation were made by several persons during the years 1945 to 1951. For the most part, the sampling for mud crabs was secondary to the collection of some other organism, such as the oyster, *Crassostrea virginica* (Gmelin), or the blue crab, *Callinectes sapidus* Rathbun. Thus, the collections are not a result of quantitative sampling. Nevertheless, consistent presence or absence of a species from similar ecological conditions was presumptive evidence of the distribution of that species.

The greater number of collections was made by the staff of the Chesa-

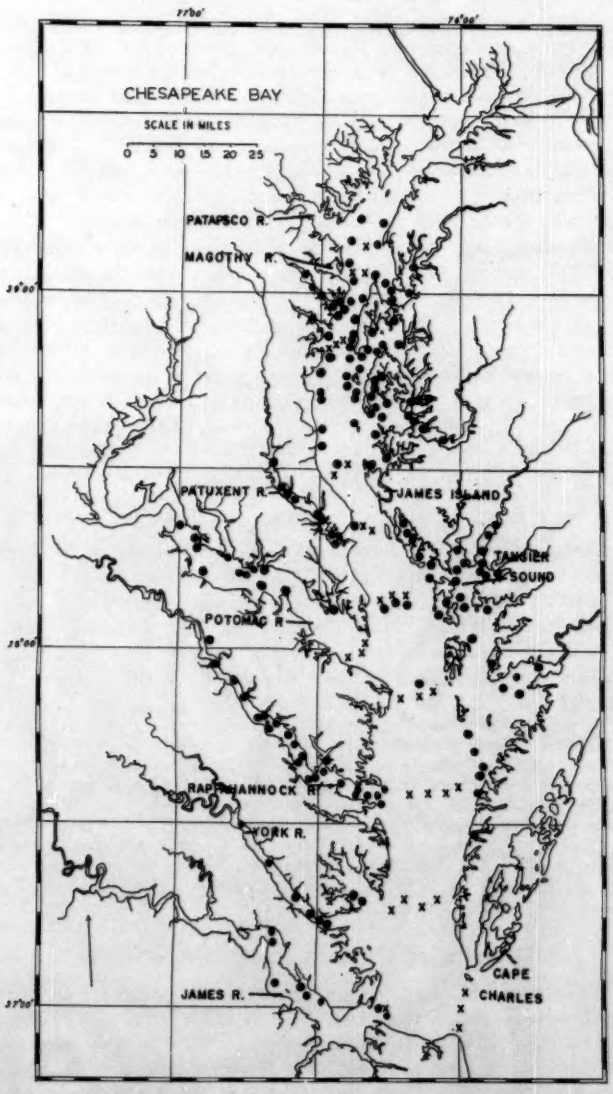

Fig. 1.—Map of Chesapeake Bay and its tributaries, showing the locations of collecting stations. Collections from stations marked with a dot were made as a part of the present study and those marked with an "X" were reported by Cowles (1930).

peake Biological Laboratory, and deposited with Dr. L. Eugene Cronin while at that institution. Other collections were made by Mrs. Helen Landau Hayes, during an investigation of the oyster parasite, *Nematopsis*, and by the author in March, 1951, on the oyster bars of the Eastern Shore. Collections were made at 189 stations (fig. 1). Preliminary observations were made by Dr. Cronin before making the collections and the pertinent data available to this study.

The crabs were collected with several types of sampling devices. The sampling gear included the oyster dredge, oyster tongs, fine-mesh oyster scrape, and crab dredge (Sieling, 1950 and Wharton, 1949). Specimens were preserved with 70 percent ethanol in the field for subsequent examination in the laboratory. Occasionally, the specimens were preserved in four percent formaldehyde and changed to ethanol in the laboratory. Ecological data recorded covered location, date, sampling gear, salinity, temperature, type of bottom and other organisms present.

The crabs were examined for morphological characters of known taxonomic importance, sex, degree of maturity and size. The taxonomy of Rathbun (1930) was followed throughout. Doubtful specimens were compared with identified specimens loaned by the United States National Museum. Size was expressed as the greatest carapace width to the nearest 0.1 millimeter as measured by micrometer calipers or ocular micrometer. It was not possible to examine the gonads for sexual maturity since as much as two years had elapsed between preservation and examination. Following the suggestions of Chace (1951), of the U. S. National Museum, the morphological conditions of the largest individuals were assumed to be those of maturity. There are two pairs of abdominal appendages in the male brachyuran. When the abdomen of the male is folded, these appendages are extended longitudinally in the ventral thoracic groove. A male was considered mature when the pleopods in folded position extended beyond the suture of the sixth and seventh thoracic sternites. Setae are present on the endopodites of the pleopods in the adult female crab and eggs are attached to them during the ovigerous stage. Presence of setae on the endopodite of the pleopods was considered indicative of maturity in the female crab.

OBSERVATIONS AND DISCUSSION

General Discussion of Xanthidae.—The mud crabs, Xanthidae, are members of the largest family of cancroid crabs. Rathbun (1930) lists 47 genera in which are found approximately 170 species. She differentiates Xanthidae from other families of cancroid crabs as follows: The carapace is transversely oval or transversely hexagonal or subquadrate, never subcircular; and always broader than long. The width of the front (interorbital margin) varies from broad to very broad and is never produced in the form of a rostrum. The antennules are folded transversely or obliquely. Antennal flagella are short and slender. The anterior margin of the buccal cavity is well defined and never overlapped by the third maxillipeds. The legs are not developed for swimming.

Most of the species listed by Rathbun inhabit tropical or subtropical waters. They are found on the east and west coasts of both North and South Amer-

ica. Fewer species are recorded north of Cape Hatteras than those recorded by Hay and Shore (1918) from the region of Beaufort, N. C., which is just south of Cape Hatteras. The following two keys to Xanthidae of Chesapeake Bay are based upon features observed in specimens examined for this study. Key I may be used to classify those xanthids which have the major chelipeds. If the major cheliped is lost, Key II may be used and is based upon the characteristics of the carapace.

I. KEY TO THE XANTHIDAE (WITH MAJOR CHELIPED) OF CHESAPEAKE BAY[2]

A. Dactyl of major chela with large basal tooth. Fingers of chelae may be dark or light. When dark, color extends only a little way back on the palm.

B. Fingers light. Front short, not projected beyond curve of antero-lateral margin ..... *Eurytium limosum* (Say)

BB. Fingers dark. Front projected well beyond curve of antero-lateral margin.

C. Carapace with transverse rows of granulations. Carpus without distal groove. ..... *Panopeus herbsti* Milne-Edwards[3]

CC. Carapace smooth, without transverse rows of granulations. Carpus with distal groove ..... *Hexapanopeus angustifrons* (Benedict and Rathbun)

AA. Dactyl of major chela without large basal tooth. Fingers of chelae may be dark or light. When dark, color extends well back on the palm.

D. Fingers of chelae light. Frontal margin transversely grooved, appearing double. ..... *Rhithropanopeus harrisi* (Gould)[3]

DD. Fingers of chelae dark. Frontal margin not transversely grooved.

E. Carapace with transverse rows of granulations. Tips of fingers of minor chelae spooned ..... *Eurypanopeus depressus* (Smith)

EE. Carapace smooth without transverse rows of granulations. Fingers of minor chela unspooned. ..... *Neopanope texana sayi* (Smith)

II. KEY TO THE XANTHIDAE (WITHOUT MAJOR CHELIPED) OF THE CHESAPEAKE BAY

A. Carapace with transverse rows of granulations.

B. Frontal margin transversely grooved. ..... *Rhithropanopeus harrisi* (Gould)

BB. Frontal margin not transversely grooved.

C. Second lateral tooth equal to or longer than first.... *Panopeus herbsti* Milne-Edwards

CC. Second lateral tooth fused with first, appearing as one. ..... *Eurypanopeus depressus* (Smith)

AA. Carapace without transverse rows of granulations.

D. Front short, not projected beyond curve of antero-lateral margin. ..... *Eurytium limosum* (Say)

DD. Front projected beyond the curve of antero-lateral margin.

E. Third lateral tooth points inward or forward, its posterior margin much longer than anterior. ..... *Neopanope texana sayi* (Smith)

EE. Third lateral tooth pointing outward, its posterior margin equal to anterior. ..... *Hexapanopeus angustifrons* (Benedict and Rathbun)

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[2] Based upon preliminary notes of W. L. Schmitt and L. E. Cronin.

[3] This name is emended to agree with the recommendations of the International Commission on Zoological Nomenclature (1950).

EURYTIUM LIMOSUM (Say)

Plate 1

Description (Modified after Rathbun (1930))—Carapace transversely oval, markedly convex longitudinally, nearly flat transversely, curving down to the lateral margin, greatest width behind fifth pair of teeth. Front short, about one-fourth width of carapace, projecting downward, with two lobes divided by shallow notch. First two lateral teeth almost completely fused. Third and fourth teeth blunt, projecting forward, posterior margin longer than anterior. Fifth tooth more sharp, its posterior margin extending as lateral margin of carapace.

Carapace appears smooth to the eye but under the lens is densely granular, especially along the antero-lateral margins. Areolations not marked, mesogastric and cardiac regions outlined.

Chelae massive, unequal, rounded, granulations fine and reticulated. Merus with subdistal groove. Carpus without groove, inner sub-distal spine slender and blunt. Finger pointed, deflexed, large basal tooth on major dactyl.

Carapace brilliant purplish blue, wrists and hands bluish, finger white except proximal upper half of dactyl pink. Lower portions of chelae and also carpal tooth yellow.

Range.—From New York to Sao Paulo, Brazil. Bermuda and Bahamas (Rathbun, 1930).

Occurrence in Chesapeake Bay.—Eurytium limosum (Say) is a tropical species and was not collected from the waters of Chesapeake Bay, but it was recorded from New Jersey by Thomas Say. The identity of the specimens received from Say, in the collections of the Academy of Natural Sciences of Philadelphia, have been confirmed by Dr. Rathbun (Chace, 1951). Hay and Shore did not report this species from the Beaufort, N. C., area. Fowler (1911) included it in his report on the basis of Say's observations. Chace (1951) suggests that if this species were to be found in the Bay, it might be in the vicinity of Cherrystone (near Cape Charles, Va.) since several subtropical forms have been found there.

Where reported, this species has been found in muddy, marsh banks which are usually covered at high tide. Benedict and Rathbun (1891) report it from the same bank with *Panopeus herbsti* Milne-Edwards forma *obesa*. Verrill (1908) found that it was rare in Bermuda but that it had been reported from a mangrove swamp by Miers in the *Challenger Reports*.

There are two possible reasons for the absence of *Eurytium* from records of collections north of South Carolina. It is conceivable that Say's collections were mixed and from another locality since in the same volume (Vol. I. Proc. Acad. Nat. Sci. Phil.), Say (1817) also described several brachyurans from the southern states. Verrill (1908) has suggested that muddy banks are habitats rarely visited by collectors. Unfortunately, such sites were not visited in the course of this investigation.

NEOPANOPE TEXANA SAYI (Smith)

Plate 1

Description (Modified after Rathbun (1930)).—Carapace subhexagonal, convex transversely and longitudinally, greatest width at fifth pair of lateral teeth. Front extended, depressed, two lobes separated by a slight notch. First two lateral teeth fused, hardly distinguishable. Fourth tooth sharp, pointing forward, deeply separated from third and fifth by a sinus. Fifth tooth sharp, pointing laterally (fig. 10A). Lateral areolations marked. Carapace appears smooth to the eye but under the lens is everywhere covered with fine granulations. The female is minutely pubescent. Third, fourth and fifth abdominal segments of male fused, terminal segment sharply triangular.

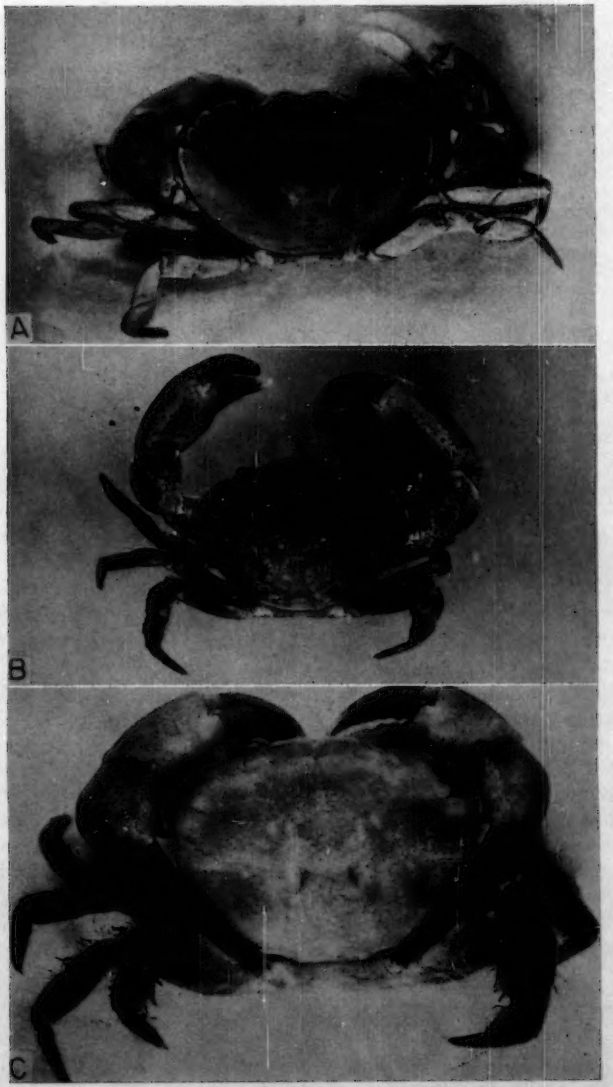

PLATE 1

Dorsal view of adult male.—A. *Eurytium limosum* (Say). Carapace width 32.3 mm; B. *Neopanope texana sayi* (Smith). Carapace width 24.3 mm; C. *Panopeus herbsti* Milne-Edwards. Carapace width 39.8 mm.

Chelae barely unequal, smooth, massive, rather blunt. Both merus and carpus with subdistal groove and blunt inner subdistal spine. Dactyl without large basal tooth. Fingers of minor chelae not spooned (fig. 8B). General appearance very similar to *Eurypanopeus depressus*. May be differentiated from *E. depressus* by the following characteristics: transversely convex carapace, nearly equal chelae, lack of granulated lines on the carapace, sharply triangular terminal segment of male abdomen, minor chelae not spooned, and lack of red spot on the inner surface of third maxillipeds.

Color, dark reddish-brown speckles on yellowish background especially on anterior portion of carapace and upper portions of chelae. Ventral portions light. Fingers dark brown. Color of fixed finger in the male extends backward, upwards and then curves downwards, that of the female extends obliquely backwards and downwards on the palm. Tips of fingers light.

Range.—Prince Edward Island, Canada. Northumberland Strait, New Brunswick. From Provincetown, Massachusetts to eastern Florida (Rathbun, 1930).

Observations on Life History.—Ovigers[4] of *N. texana sayi* were not collected in the present investigation. Cowles found them during July in the offshore waters. He also found juveniles only during the fall, winter and spring cruises. He concluded that summer was the spawning season and that the juveniles reach maturity by the first summer after hatching. Hyman (1925) amplified the work of Birge (1883) on the larval history of this species. It was Hyman's conclusion that there are nine molts between the prezoeal and first crab stages. He collected the pre-, first and second zoeal stages in the "tow", but the third and fourth zoeal and megalops stages were collected from the bottom. Neither Hyman nor Birge gives indication of the size of the first crab stages. Data were also lacking in the present study on the size at which maturity is reached in the males. The only immature specimen collected in this study was a female 5.1 mm in carapace width. It was collected on August twenty-first. Four mature males were collected having carapace widths of 12.3, 15.5, 16.2, and 19.5 mm. Mature females were collected at widths of 6.1, 9.3, 13.7, 15.5, 17.7, 18.4, and 18.7 mm, suggesting that maturity is probably reached in the female of this species at approximately 5-6 mm. If this were true, the size range of mature females would be at least 13 millimeters, or about 70 percent of the recorded size range of the female. Such a wide size range has been found in *Eurypanopeus depressus*. Rathbun has recorded the width of a male of this species at 27.0 mm, the largest recorded measurement of this sex. The data obtained by workers to date are insufficient to determine the size range of mature males of this species. More study of *Neopanope texana sayi* is needed before the life history can be known.

Occurrence in Chesapeake Bay.—This species was collected in small numbers at the stations visited in the course of the study. Twelve specimens were recorded from five stations (fig. 2). Only one specimen was found north of the mouth of the Potomac River. Although Cowles reported this species only from south of the Potomac, he recorded it in greater quantity than any crab collected in the offshore waters. The single specimen from the upper bay was found on Belvedere Shoal, which is located mid-Bay just below the mouth of the Patapsco River. Miss Rathbun listed many records

[4] This term is suggested by the author and used herein to denote egg-bearing females.

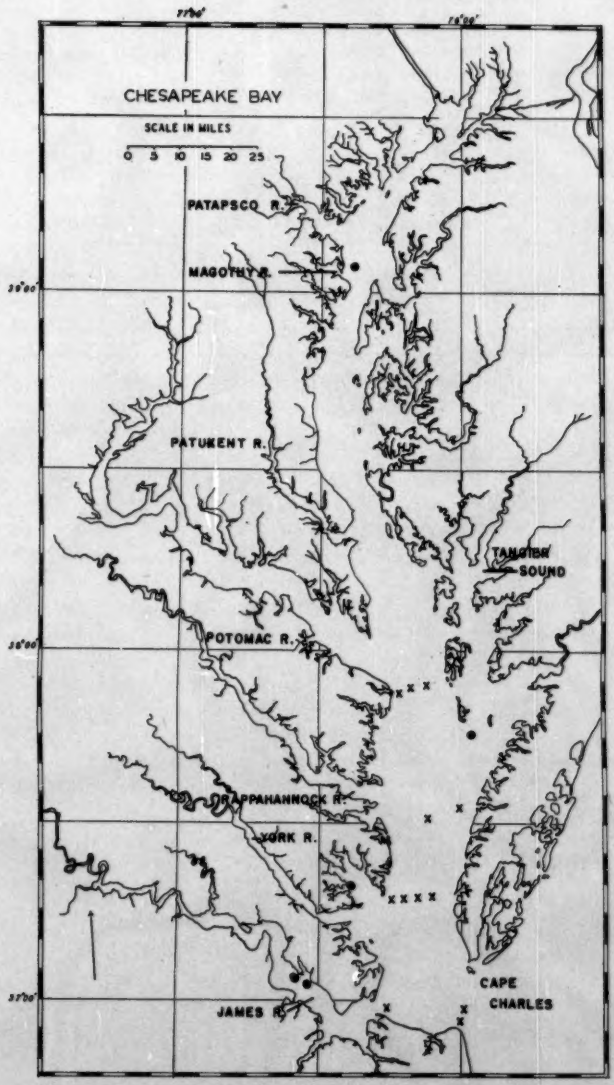

Fig. 2.—Occurrence of *Neopanope texana sayi* in Chesapeake Bay. Dots mark areas where collections were made in this study and "X's" mark those of Cowles (1930).

of this species from the Chesapeake Bay; however, she listed only one station north of the Potomac at the mouth of the Magothy River, about three miles below Belvedere Shoal.

The ecological conditions under which *Neopanope* was collected in this study were similar to those found by others. The specimens were collected at depths of 13 to 100 feet. Dr. Rathbun indicates that specimens from Chesapeake Bay examined by her were reported from 22 to 150 feet. In the Woods Hole region, Sumner, Osborn and Cole (1911) found the species at depths of 12 to 102 feet and on all sorts of bottom, especially in muddy places and on piles among algae. McDermott and Flower (1952) considered it the most common species of mud crab in Delaware Bay. It was found to be scarce along the littoral area of the Bay and in regions of low salinity. On the other hand, they found it to be especially abundant on the oyster beds of the Bay proper where the "red beard sponge", *Microciona prolifera,* is found, often living in the sponge. Landers (1954) also found it abundant in the hard clam areas under study at Narragansett Bay, where it is considered a menace. All specimens found in the present study were from muddy bottoms on which were scattered shells. The salinity range for this species, as reported by Cowles, was 14.79 to 31.62 per mille (parts per thousand). The salinity range of the species in the present study was 14.66 to 18.30 per mille. The one specimen from the northern half of the Bay was collected from a salinity of 14.66. However, it should be noted that this was collected in October of 1946, which, according to Engle (1946), was a year of drought and exceptionally high salinity in the upper Bay. In the papers of Birge (1883) and Cowles (1930) the species is recorded in abundance; however, the infrequency of occurrence in the present investigation indicates that *Neopanope texana sayi* may have declined in number in recent decades.

PANOPEUS HERBSTI Milne-Edwards

Plate 1

Description (Modified after Rathbun (1930)).—Carapace subhexagonal, transversely and longitudinally convex, greatest width at fifth pair of lateral teeth. Front about one-fourth to one-third of greatest carapace width, projecting, two lobes divided by shallow sinus, margin granular. First two lateral teeth separated by shallow sinus, second larger, extending almost as far forward as first. Third tooth spine-tipped, pointing inward, outer margin arcuate. Fourth tooth separated from third and fifth by deep sinus, spine-tipped, pointing forward. Fifth tooth spine-tipped, pointing forward, shorter than fourth (fig. 9A). Areolations well raised, especially the branchial. Several pairs of granulate transverse lines including: behind front, median to sinus of fourth and fifth lateral teeth, and extending inward from tip of last tooth. Carapace sparingly pubescent. Male abdomen five-segmented; third, fourth and fifth segments fused; third segment extending to coxae of last pair of periopods; sixth segment almost as long as wide; terminal segment rounded. Walking legs very hairy, fifth pair appearing dorsal to fourth.

Chelae (fig. 4B) unequal, with ridge on upper surface. Carpus (fig. 5B) without subdistal groove and with blunt, inner, subdistal spine. Major dactyl with large basal tooth. Fingers not hooked, manus with tooth opposing that of dactylus. Upper surface of the segments of the cheliped granular.

Color a dark gray or slate color above, usually stained by mud. Under parts lighter. Fingers dark, color extending a little way back on palm.

Rathbun (1930) has separated this species into several forms. She did not consider the differences in morphology sufficient for separation into sub-

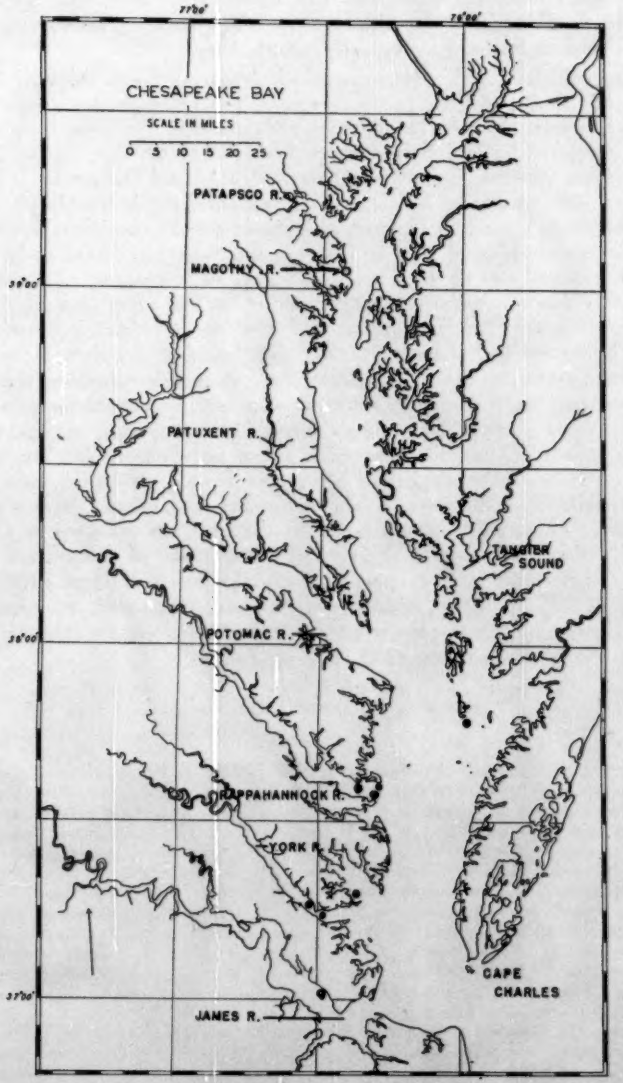

Fig. 3.—Occurrence of *Panopeus herbsti* in Chesapeake Bay. Dots mark areas where collections were made in this study. The hollow circle represents a published record.

species or varieties. The typical form is the one described above and the only one found in Chesapeake Bay.

Range.—The range of the species is from Boston, Massachusetts, to Florianopolis, Brazil. The range of the typical form is more northern than those of other forms (Rathbun, 1930).

Observations on Life History.—Neither ovigers nor immature individuals of this species were collected on the Bay during this investigation. Dr. Rathbun listed the collection of an oviger from the Bay on July 22. Lunz (1937) found ovigers of *P. herbsti* in the Carolinas on May 15 and throughout the summer months. Spawning presumably occurs in the Bay during the summer. The size at which maturity is reached is not yet known. The carapace widths of mature males collected in this study were 8.3, 15.6, 21.5, 22.4, 32.3, 33.2, 35.0, 35.6, 36.6, and 37.3 mm. The carapace widths of mature females 21.6, 22.7 and 27.8 mm. More study is needed to complete the details of the life history of *Panopeus herbsti* in Chesapeake Bay.

Occurrence in Chesapeake Bay.—Few individuals of this species were collected from the Bay in the course of the investigation. The locations of the nine stations from which it was collected are shown in fig. 3. All stations were below the mouth of the Potomac River. Miss Rathbun has recorded the collection of *P. herbsti* at one station north of the Potomac River, in Magothy Bay. The salinity from which *P. herbsti* was collected varied from 13.95 to 19.04 per mille. The depths of stations ranged from 13 to 35 feet. The type of bottom recorded at each station was soft mud with few oyster shells. Other workers have indicated that this species is not common north of Cape Hatteras. Cowles reported the collection of this species from the lower Bay in his study of the offshore waters. Blake (1953) has recorded *Panopeus herbsti* from Wailes Bluff and Langleys Bluff, St. Mary's County, in Pleistocene deposits on the eastern bank of the Potomac River a few miles above its mouth. McDermott and Flower (1953) found this species three-quarters of the way up the natural oyster beds of Delaware Bay, but it was

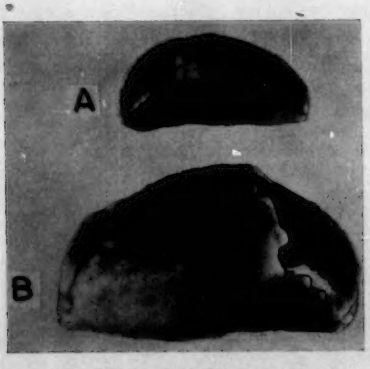

Fig. 4.—Major chela. A. *Eurypanopeus depressus*. B. *Panopeus herbsti*.

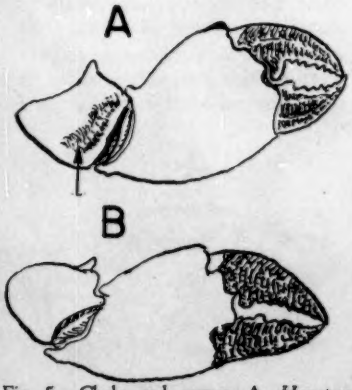

Fig. 5.—Chela and carpus. A. *Hexapanopeus angustifrons*. B. *Panopeus herbsti*.

not common in this northern limit. It was most common in the Bay proper where it and *Neopanope* were the dominant species. Experiments have indicated that the "large mud crabs," of which *Panopeus* is a member, are selective in their feeding on thin-shelled oysters under laboratory conditions. *Panopeus* will chip the margins of the valves of oysters until they get to the soft parts, but there is no evidence as yet that it is a serious predator.

HEXAPANOPEUS ANGUSTIFRONS (Benedict and Rathbun)

Plate 2

Description (From Rathbun, 1930).—Carapace convex, smooth. Front narrow (fig. 6B), produced beyond curve of antero-lateral margin, four lobed, lateral lobes small, median notch v-shaped. Lateral teeth ascending. First and second teeth fused, separating-sinus shallower in adult than in young. Third tooth short and broad, pointing outward. Fourth tooth with posterior margin a little longer than anterior and subparallel to median line. Fifth tooth shorter and sharper (fig. 10B).

Chelae unequal. Merus with sometimes two subdistal spines. Carpus (fig. 5A) with deep distal groove and subcylindrical spine. Major palm swollen, fingers gaping. Dactylus of major chela with large basal tooth. Legs slender, dactylus long and hairy.

Third, fourth and fifth segment of male abdomen partially ankylotic, third segment not as wide as first, its outer ends rounded.

Color variable, brownish yellow to reddish brown. The females are usually darker than the males. Color of movable ends abruptly at palm in adults, in young it ends just distal to the palm.

Range.—From Massachusetts (Vineyard Sound) to Gulf of Mexico, Bahamas and Jamaica (Rathbun, 1930).

Observations on Life History.—Few specimens of this species were collected from Chesapeake Bay. Ovigers and immature specimens were not observed during the course of this study. Cowles reported the collection of one oviger at the mouth of the Bay during the month of July. Those ovigers listed by Rathbun were collected off the Atlantic coast at depths of sixty feet or more, and during the summer months. The species possibly does not spawn in the Bay, but enters as planktonic larvae. Mature males collected during study varied in width from 9.7 to 28.9 mm which is 68 percent of the total recorded size range. Mature females ranged in size from 8.4 to 20.2, 59 percent of the total size range. Dr. Rathbun reports that specimens of *H. angustifrons* from Chesapeake Bay were smaller than those from northern waters. Specimens were collected during this investigation which had a greater width than any recorded by her and may be of record size. The large specimens collected in this study have been deposited in the U. S. National

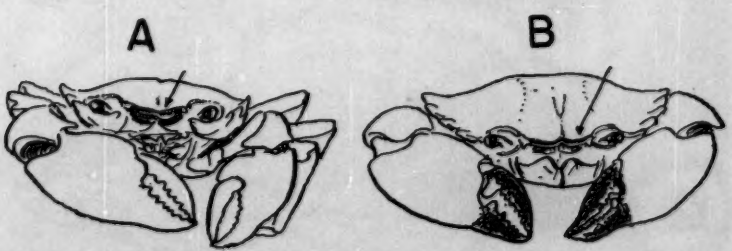

Fig 6.—A. *Rhithropanopeus harrisi*, arrow showing groove in frontal margin. B. *Hexapanopeus angustifrons*, arrow showing frontal margin without groove.

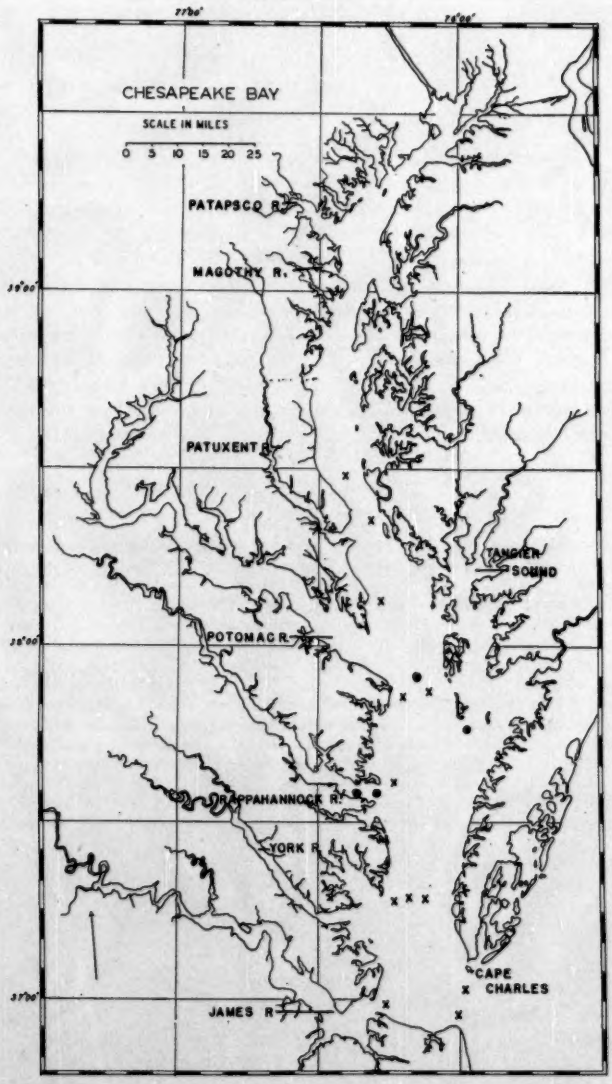

Fig. 7.—Occurrence of *Hexapanopeus angustifrons* in Chesapeake Bay. Dots mark areas where collections were made in this study and "X's" mark those of Cowles (1930).

Museum. Much is yet to be learned about the life history of this offshore species.

Occurrence in Chesapeake Bay.—Approximately twenty individuals of this species were collected at five stations in the course of this study. Unfortunately, the ecological data accompanying many of these were destroyed in a fire. The following statements are based upon the remaining but limited data. The stations from which *H. angustifrons* were collected were in the lower half of the Bay, as shown in fig. 7. Cowles reported collections of this species below James Island, Maryland, in the offshore waters. Stations used in this study from which individuals were collected varied from 35 to 100 feet in depth. Only two specimens were collected at depths of less than 60 feet. The collections of Cowles were made at depths varying from 28 to 150 feet and salinities of 18-32 per mille. Although Rathbun (Cowles, 1930) records the collection of *H. angustifrons* from the oyster bars of the New England coast, the species was not collected from the oyster bars of the Chesapeake Bay. McDermott and Flower (1952) found it only in the southern portion of Delaware Bay proper and it was the least common of the five species of mud crabs.

EURYPANOPEUS DEPRESSUS (Smith)

Plate 2

Description (Modified after Rathbun, 1930).—Carapace not markedly convex transversely or longitudinally, transversely oval, greatest width at fourth pair of lateral teeth. Areolations well defined. Carapace covered with fine granulations and several pairs of transverse rows of granulations, a granulate line extending from interorbital tooth to lateral margin of front. Front slightly arcuate, projected, two lobes divided by minute median notch which is not followed by a groove. First two lateral teeth completely fused, third tooth blunt, pointing inward, outer margin arcuate. Fourth and fifth teeth spine-tipped, pointing obliquely upward and forward (fig. 9B). Outer margins of all lateral teeth granulate. Male abdomen five segmented, third, fourth and fifth segments fused: Sixth segment narrows toward fifth. Seventh or terminal segment triangular with rounded tip.

Chelae very unequal. Merus with small subdistal spine at inner angle, slight subdistal groove. Carpus with similar spine and slight subdistal groove. Major chela (fig. 4A) heavy, propodal finger horizontal, dactyl hooked. Distal portion of minor chela spooned (fig. 8A), closely fitting, proximal portion finely denticulate. Third maxilliped with oval red spot on inner surface of ischiopodite. Ambulatory legs finely hairy, fifth pair appearing dorsal to fourth.

Color dark olive brown, especially on upper surfaces of chelipeds and anterior portions of carapace. Fingers dark brown, the dark color of the fixed finger in the male extends backward, upward and then downward on the palm. In the females, the dark color of the fixed finger extends obliquely backward and downward on the palm. Carapace and chelipeds light colored underneath.

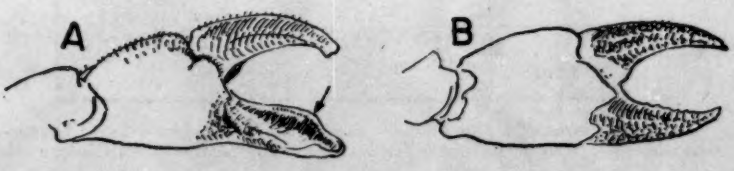

Fig. 8.—A. *Eurypanopeus depressus*, showing spooning of minor chela. B. *Neopanope texana sayi*, showing minor chela without spooning.

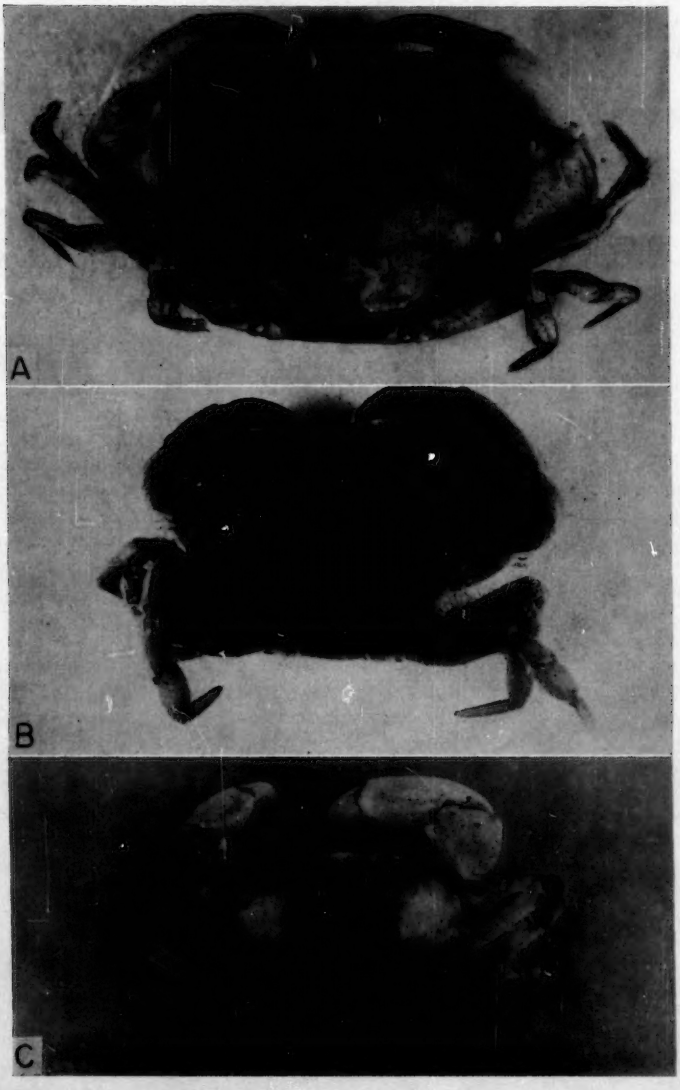

PLATE 2

Dorsal view of adult male.—A. *Hexapanopeus angustifrons* (Benedict and Rathbun). Carapace width 23.4 mm; B. *Eurypanopeus depressus* (Smith). Carapace width 13.9 mm; C. *Rhithropanopeus harrisi* (Gould). Carapace width 9.9 mm.

Measurements of adults: Males, size range 5.1 to 26.2 mm mean 12.7 mm, standard deviation of 4.72 mm, and coefficient of variation 30.9 percent, based on 475 specimens. Females, size range 5.5 to 20.6 mm, mean 10.4 mm, standard deviation 3.01 mm, and coefficient of variation 28.9 percent, based on 459 specimens.

Undescribed Morphological Features.—Two morphological variations which have not been described previously were noted in the examination of *E. depressus* from the Bay. A blood-red spot is found on the inner surface of the third maxillipeds of both sexes of *Eurypanopeus depressus*. This spot was first observed by Dr. L. E. Cronin. The spot or structure is oval and occupies a central position on the inner surface of the ischiopodite. Its length is approximately two-thirds that of the segment. The surface of the red spot is only slightly raised above the surrounding surface of the segment. When pressure was applied, the spot cracked and was easily dissected out. The spot is about 0.3 to 0.5 mm thick, and harder than the exoskeleton which surrounds it. The red spot was observed in each of more than one thousand specimens of *E. depressus* regardless of sex or size. Specimens of this species collected from Core Sound at Beaufort, N. C., and from Delaware Bay, also exhibited this spot. The striking color, consistent presence and shape of the spot suggest its use as an excellent taxonomic feature for *E. depressus*. A similar spot was found in one other species, *Panopeus herbsti*. An insufficient number of specimens of *P. herbsti* was examined; however, the spot in this species was smaller and basal. Other species observed in this study did not show any apparent variation in the consistency of the exoskeleton on the inner surface of the third maxillipeds. Histological study is needed to determine the structure and possible function of the red spot.

Variations in the structure of the male abdomen were observed in two specimens of this species from the Rappahannock River and in two from the York River. In the normal male the abdomen is narrow and the third, fourth and fifth segments are fused. The variant males had a wide abdomen with seven segments, so that they resembled females. They were first considered females but when the abdomen was lifted, the male copulatory pleopods were observed. Dr. Rathbun records a southern species, *Eurypanopeus dissimilis* (Benedict and Rathbun), in which the third segment of the male abdomen was not fused with the fourth. Other taxonomic features indicated that these variants were *E. depressus*.

Range.—From Massachusetts Bay to Florida (east and west coasts) and Texas; St. Martin, West Indies. Bermuda (Rathbun, 1930).

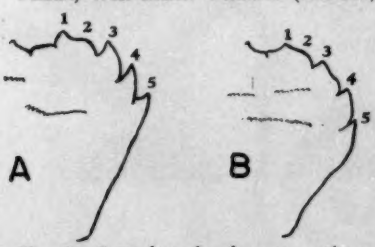

Fig. 9.—Lateral teeth of carapace (numbered). A. *Panopeus herbsti*. B. *Eurypanopeus depressus*.

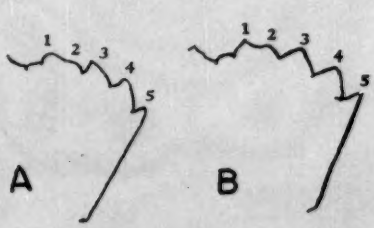

Fig. 10.—Lateral teeth of carapace (numbered). A. *Neopanope texana sayi*. B. *Hexapanopeus angustifrons*.

Observations on Life History.—Thirty-five ovigers were collected during the months of June to September. Cowles reported the presence of ovigers during April in the offshore waters of the Bay. Few stations were visited in the present study during the months of April and May and it is probable that ovigers may be found during this time. Hyman (1925) studied the prozoeal and first zoeal stages of this species in detail. He reported that their development was similar to that of *N. texana sayi.* All of the larval stages were collected by him in tow nets during the summer, thus they are, presumably, planktonic. The size of the first crab stage is unknown. Immature males collected in this investigation ranged in width from 3.2 to 6.0 mm and females from 3.6 to 6.4 mm. Maturity is probably reached at 5.1 to 6.0 mm in the males and 5.5 to 6.4 mm in the female.

Adult crabs of this species had a wide range of size. The statistical features of female *E. depressus* are shown in table 1, along with those of three other brachyuran species. Hiatt (1948) reported that males and females of *Pachygrapsus crassipes* continue to grow and molt after maturity is reached. Females of *Callinectes sapidus* were reported by Churchill (1918) to cease growth after maturity was reached and die without completing another molt. A population of adult female *P. crassipes* would be composed of individuals in each of several instars, in contrast to a population of *C. sapidus* which would be composed of crabs of but one instar. The variation in size of female *E. depressus* could be due to variations in size within one instar and/or variations over several instars. The coefficient of variation of width of female *P. crassipes* as reported by Hiatt was 15.21 percent. The variation of width of adult females of *C. sapidus* was 7.9 percent.

Females of *E. depressus* have a high (28.9) percent coefficient of variation as do females of *P. crassipes.* Such a high variation may indicate that the variation in females of *E. depressus* is the result of continued growth and ecdysis after maturity is reached. This may be further substantiated by the absence of immature females at or near the mean width of adults. The carapace widths of ovigers also showed a wide variation. Thirty-four ovigers ranged in width from 6.4 to 17.0 mm. From these observations these conclusions might be made: (1) Since soft crabs and ovigers have only been

TABLE I.—Statistical analysis of mature females of four brachyuran species.

Species	Dimension	No. indiv.	Range (mm)	Mean (mm)	Std. Dev. (mm)	Coef. Var. (%)
Pachygrapsus crassipes*	width	"several hundred"	15.0-39.7	30.9	4.7	15.5
Callinectes sapidus**	length	2833	41.0-88.0	62.2	4.7	7.9
Eurypanopeus depressus	width	459	5.5-20.6	10.3	3.0	28.9
Rhithropanopeus harrisi	length	391	4.4-12.6	7.2	1.3	18.0

* Hiatt (1948). ** Cronin (unpublished data).

found during the summer months, growth and ovulation take place during those months; (2) Several molts probably take place between the first crab stage and that stage at which maturity is reached. Maturity then might not be reached until the first summer after the eggs have hatched.

The adult males of *E. depressus* exhibit a higher coefficient of variation (31.04 percent) with respect to size than the females (28.99 percent). This suggests that males also grow after maturity is reached. Inspection of frequency distribution of carapace width gave no indications of the possible number of instars. Further study is needed to determine the number of instars and probable maximum age of this species.

Occurrence in Chesapeake Bay.—This species was found in greater numbers on the oyster bars of the Chesapeake Bay than any other mud crab. The average number of individuals of this species was 14 per station in a series of collections from twenty stations on the Eastern Shore. The average number of *Rhithropanopeus harrisi,* the only other xanthid found at these stations, was four. More than one thousand specimens were examined from 129 stations on the Bay. These stations are shown in fig. 11. *E. depressus* was collected at depths varying from 6 to 60 feet. Many of the stations visited during this study were from 6 to 30 feet deep; it was within this range that *E. depressus* was most abundant. This species was collected at depths of over thirty feet at but five stations. At each of these stations only one or two individuals were recorded. The salinities of stations at which this species was collected ranged from 4.5 to 20.4 per mille. Cowles reported the species from depths of 36 to 150 feet in the offshore waters of the Bay. The distribution of *E. depressus* is probably limited neither by depths nor by those estuarine salinities above 4.5 per mille.

A survey[5] was made of the Rappahannock River in February and March, 1950. Quantitative methods were used. Collecting stations were selected on a series of transects at intervals up stream from its mouth to Island Point, a distance of approximately 60 miles. The salinity at specific stations varied from 18.0 at the mouth to 0.8 per mille at Island Point. Standard dredge hauls were made at intervals on each transect. The distribution of *E. depressus* with respect to the oyster is shown in table 2.

These data indicate that there is a high coincidence of oyster (or shells) with *Eurypanopeus depressus.* Either food or shelter may be the possible

TABLE 2.—Coincidence of *E. depressus* and the oyster, *Crassostrea virginica* on the Rappahannock River, 1950.

No. stations with *E. depressus* and without oysters	0
No. stations with *E. depressus* and oysters	13
No. stations with oysters and without *E. depressus*	6
No. stations with neither	37
No. stations recorded as "Mud crabs not kept"	12

[5] The survey was a cooperative investigation made by the Chesapeake Biological Laboratory, Solomons, Md.; Virginia Fisheries Laboratory, Gloucester Point, Va. and the U. S. Fish and Wildlife Service. Permission to use the data was generously given.

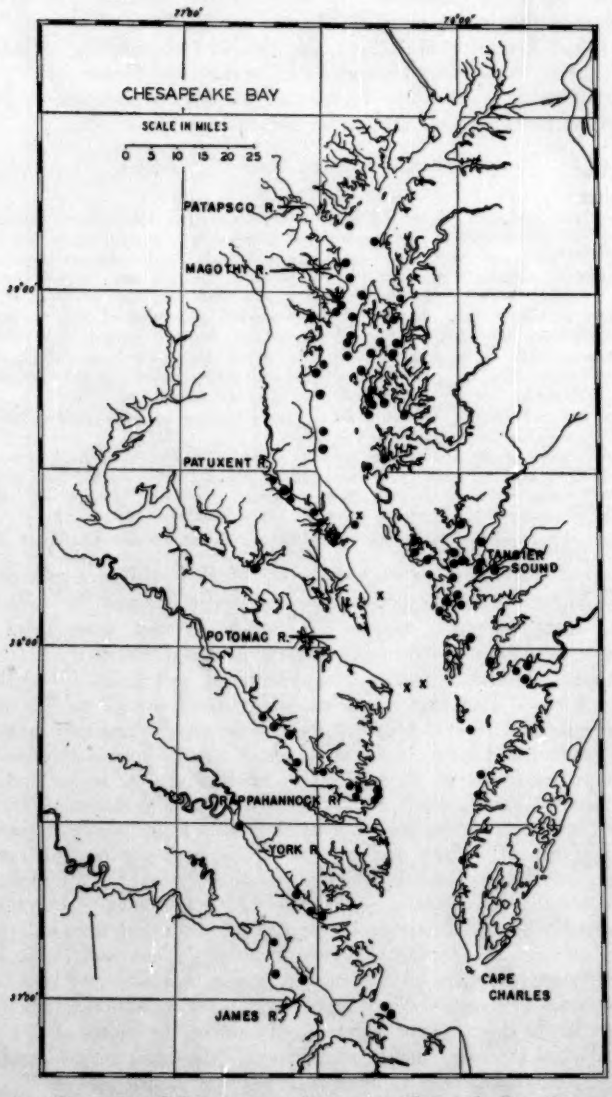

Fig. 11.—Occurrence of *Eurypanopeus depressus* in Chesapeake Bay. Dots mark areas where collections were made in this study and "X's" mark those of Cowles (1930).

factor leading to the coincidence. *E. depressus* was collected from other types of shelter in this study, especially the red sponge *Microciona sp.* Paulmeir (1905) and Fowler (1911) have also described the affinity of individuals of this species for sheltered places. McDermott and Flower (1952) found it to be abundantly distributed in most of the areas investigated in Delaware Bay, except for the middle and upper portions.

RHITHROPANOPEUS HARRISI (Gould)

Plate 2

Description (Modified from Rathbun, 1930).—Carapace subquadrate, greatest width at fourth pair of lateral teeth, transversely and longitudinally convex. Front not produced, margin with transverse groove (fig. 6A), appearing double. Aerolations prominent with many rows of transverse granulations, especially in the epigastric, cardiac and lateral regions. Lateral teeth not prominent, first and second teeth completely fused. Third, fourth and fifth teeth blunt, pointing obliquely upward. Abdomen of male five-segmented, third segment not reaching coxae of last pair of legs, terminal segment with rounded tip.

Chelae unequal, dactyl without large basal tooth. Carpus with subdistal groove and tooth at inner angle. Upper surface of carpus and chelae granular in juveniles, smooth in adults. Ambulatory legs fine. Antennules with black chromatophores.

Color brownish with maroon blotches on cream background, often stained with bottom mud. Chelae light with spots on upper surface.

Measurements of adults: Male, size range 4.1 to 14.6 mm, mean 8.04 mm, standard deviation 2.31, and coefficient of variation 28.37 percent, based on 527 individuals. Females, size range 4.4 to 12.6 mm, mean 7.25 mm, standard deviation 1.31 mm, and coefficient of variation 18.06 percent, based on 391 individuals.

Range.—From Miramichi estuary, New Brunswick, to Mexico (Rathbun, 1930).

Observations on Life History.—Ovigers of *R. harrisi* were collected from June to September for the present study. Cowles reported the collection of ovigers during the same months. Although juveniles were found at all months of the year, they were more frequent in the collections made from July to October. Immature forms of undetermined sex varied in width from 2.2 to 3.6 mm. Immature males ranged in size from 3.2 to 5.0 mm and immature females from 3.3 to 5.7 mm. Maturity is probably reached the second summer at 4-5 mm in the males and 4.4 to 5.5 mm in the females.

Mature specimens of *R. harrisi* were observed to be several millimeters larger than the size at which maturity is reached. The statistical features of the females of this species are compared in Table 1 with those of three other brachyuran species. Males and females of this species grow and molt after maturity is reached as has been recorded for *E. depressus*. The males grow to a larger size than the females (size range 4.1 to 14.6 mm). Hiatt (1948) has ascribed a similar difference in the size of males and females of *Pachygrapsus crassipes* to the fact that the females do not molt while in the ovigerous stage. Ovigers of *R. harrisi* ranged in size from 4.8 to 12.6 mm. The frequency of carapace widths failed to give any indication of the numbers of instars in the crab stage of *R. harrisi*. However, the widths of 251 mature males collected from one station at Solomons, Maryland, were plotted. The curve obtained indicates that there may be four instars between 5 and 10 mm. Measurements before and after ecdysis are necessary in order to determine the number of instars and size increment of each ecdysis.

Occurrence in Chesapeake Bay.—*Rhithropanopeus harrisi* was collected from stations under many diverse conditions. Approximately one thousand speci-

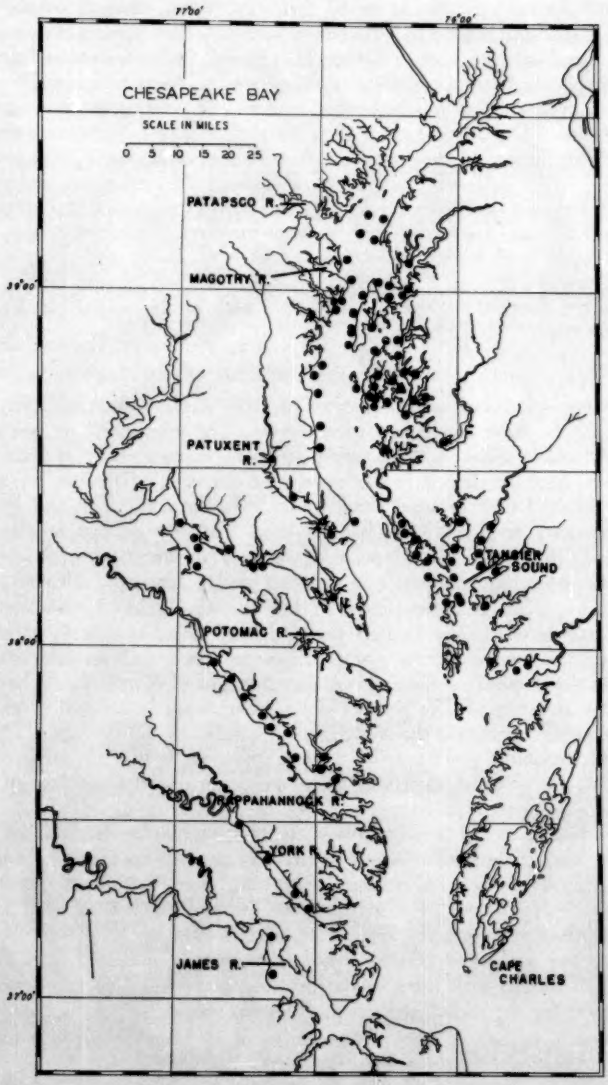

Fig. 12.—Occurrence of *Rhithropanopeus harrisi* in Chesapeake Bay. Dots mark areas where collections were made in this study.

mens were collected at 113 stations (fig. 12) on Chesapeake Bay. Depths of these stations ranged from 0 to 30 feet. Salinities, when recorded, ranged from 2.8 to 18.6 per mille. *R. harrisi* was the only species studied which also is found in fresh water. Fowler (1911) collected this species from fresh water in the Elk River, Cecil County, Maryland. The salinities of the stations visited in the course of this investigation were not limiting in the distribution of *R. harrisi.* Depths of greater than thirty feet may have an indirect effect on the distribution of this species. Individuals were always collected from a bottom which afforded some type of shelter. The types of shelter from which this species was collected were more diverse than those of *E. depressus.* Although *R. harrisi* was collected in large numbers from oyster bars, it was also collected from many other types of shelter: living and decaying vegetation, branches, can and other debris. McDermott and Flower (1952) found it to be the dominant species in the upper part of the natural seed beds in Delaware Bay.

DISCUSSION

The ecological conditions reported in this study were necessarily those at the specific time collections were made. The conditions at one station may vary widely within a short period of time. A complexity of factors contributes to constant change in the ecology of estuaries. Salinities are affected by the ebb and flow of tide, precipitation, weather conditions and by many other factors. Engle (1946) has reported that the salinity in the upper Chesapeake may drop from 15 per mille to 0 within one month. Accordingly, individual crabs are subjected to constant and often rapid changes in the environment. Single observations on the chemical and physical conditions at one station yield very limited knowledge of these conditions throughout the year. The movement of water masses landward and seaward may play a part in the dispersion of planktonic larval stages of Xanthidae. The Chesapeake Bay Institute of The Johns Hopkins University is engaged in an extensive research program on the hydrographic conditions of the Bay. This program will, no doubt, make possible a fuller understanding of the environmental conditions, the unusual variations that take place and the problem of movements of various water masses.

The distribution of xanthids may be affected by the methods of oyster culture. Young seed oysters are moved from one bar to another for further growth (Truitt, 1939). Oysters may be transferred in this way to growing bars many miles distant. For instance, the James River has supplied seed for Maryland beds for many years. Seed oysters also are imported from the Delaware Bay and other points. Mud crabs may be collected with the seed oysters and moved with them to the planting ground. This may account to some extent for the wide distribution of certain species.

SUMMARY

Five species of xanthid crabs have been collected from 189 stations on Chesapeake Bay. These crabs, commonly called mud crabs, may act as alternate hosts of a sporozoan parasite of the oyster. Observations were made on the life history and distribution of all species collected. A sixth species,

Eurytium limosum, has been recorded north and south of the Bay, but not found during this investigation.

Three species were not abundant. *Neopanope texana sayi* was collected only from inshore waters in the south of the Bay. *Panopeus herbsti* only was present in the collections from stations with salinity above fourteen. *Hexapanopeus angustifrons* was the only species confined to the deeper waters of the Bay.

Eurypanopeus depressus was the most abundant species collected. A red spot was observed on the third maxillipeds and is suggested as a taxonomic feature. This species was confined to bottoms on which some type of shelter was present, usually an oyster bar.

Rhithropanopeus harrisi was quite abundant and was collected in large quantities. The observations on the life history were similar to those of *E. depressus*. *R. harrisi* was found in shallow waters and is the only species of mud crab recorded from fresh water.

Sufficient numbers of the last two species were collected to present a substantial description of both species.

LITERATURE CITED

BENEDICT, J. E. AND M. J. RATHBUN 1891.—The genus *Panopeus*. Proc. U. S. Nat. Mus. 14:335-385.

BIRGE, E. A. 1883—Notes on the development of *Panopeus sayi* Smith. Studies Biol. Lab. Johns Hopkins Univ. 2:411-426.

BLAKE, S. F. 1953—The Pleistocene fauna of Wailes Bluff and Langleys Bluff, Maryland. Smithsonian Misc. Coll. 121(12):1-32.

CARRIKER, M. R. 1951—Personal communication.

CHACE, F. A., JR. 1951—Personal communications.

CHURCHILL, E. P., JR. 1919—Life history of the blue crab. Bull. U. S. Bur. Fish. 36: 99-160.

COWLES, R. P. 1930—A biological survey of the offshore waters of Chesapeake Bay. Bull. U. S. Bur. Fish. 46:277-281.

ENGLE, J. B. 1946—Commercial aspects of the upper Chesapeake Bay oyster bars in the light of recent oyster mortalities. Third Ann. Rept. Md. Bd. Nat. Res.:134-140.

FERGUSON, F. F. AND E. R. JONES 1949—A survey of the shore-line fauna of the Norfolk Peninsula. Amer. Midl. Nat. 41(2):436-446.

FOWLER, H. W. 1911—The Crustacea of New Jersey. Ann. Rept. N. J. St. Mus. 29-650.

HAY, W. P. AND C. A. SHORE 1918—The decapod Crustacea of Beaufort, N. C. and the surrounding region. Bull. U. S. Bur. Fish. 35:369-475.

HIATT, R. W. 1948—The biology of the lined shore crab, *Pachygrapsus crassipes* Randall. Pac. Sci. 2:135-213.

HYMAN, O. W. 1925—Studies on the larvae of crabs of the family Xanthidae. Proc. U. S. Nat. Mus. 67:1-22.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE 1950—The official record of proceedings of the International Commission on Zoological Nomenclature at its session held in Paris in July, 1948. Bull. Zool. Nomen. 4(1-12):1-350.

KUDO, R. R. 1939—Protozoology. Charles C Thomas. Springfield, Ill.

LANDERS, W. S. 1954—Notes on the predation of the hard clam, *Venus mercenaria*, by the mud crab, *Neopanope texana*. Ecology 35(3):422.

LUNZ, G. R., JR. 1937—Xanthidae (Mud crabs) of the Carolinas. Charleston Mus. Lft. 9:9-28.

McDERMOTT, J. J. AND F. B. FLOWER 1952—Preliminary studies of the common mud crabs on oyster beds of Delaware Bay. Nat. Shellfish. Assoc., 1952 Convention Addresses:47-50.

PAULMEIER, F. P. 1905—Higher Crustacea of New York City. Bull. St. Mus. N. Y. 91:117-189.

PRYTHERCH, H. F. 1940—The life cycle and morphology of *Nematopsis ostrearum*, sp. nov., a gregarine parasite of the mud crab and oyster. J. Morph. 66:39-64.

RATHBUN, M. J. 1930—The cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae. Bull. U. S. Nat. Mus. 152: 1-593.

SAY, T. 1817—An account of the crustacea of the U. S. Proc. Acad. Nat. Sci. Phila. Vol. 1, Pt. 1.

SIELING, F. W. 1950—Maryland's commercial fishing gears. II. Oyster gears. Ches. Biol. Lab. Ed. Ser. 25:1-24.

SUMNER, F. B., R. C. OSBURN AND L. J. COLE 1911—A biological survey of the waters of Woods Hole and vicinity. Bull. U. S. Bur. Fish. 31:1-860.

TRUITT, R. V. 1939—Our water resources and their conservation. Ches. Biol. Lab. Contrib. 27:1-103.

——— 1945—Annual Report, 1945: Maryland Department of Research and Education: crabs. Second Annual Report, Maryland Board of Natural Resources:59-61.

——— 1947—Annual Report, 1947: Maryland Department of Research and Education: crabs. Fourth Annual Report, Maryland Board of Natural Resources:118-125.

VERRILL, A. H. 1908—Decapod Crustacea of Bermuda. I. Brachyura and Anomura: their distribution, variation and habits. Trans. Conn. Acad. Arts and Sci. 13: 299-474.

WHARTON, J. 1949—The Chesapeake crab industry. U.S. Fish and Wildlife Serv. Lft. 348:1-13.

A New Crayfish of the Genus Orconectes From Illinois (Decapoda, Astacidae)[1]

Paul L. Brown
Southern University, Baton Rouge, Louisiana

The crayfish described here was discovered while the author was carrying out an investigation on the biology of the crayfishes of central and southeastern Illinois.[2] According to the collection data compiled during this investigation, this crayfish is limited in distribution to the southern part of Illinois and was not found in the collections which were made in the eastern and central parts of the state.

Orconectes illinoiensis sp. nov.

Diagnosis.—Eyes and carapace pigmented; rostrum usually bearing prominent lateral spines, concave above, sides concave with concavity varying from slight to medium; areola of medium width, 4-5 times as long as broad with three to four punctations in narrowest part. Branchiostegal spine present; ischiopodites of third pereiopods of males bearing hooks. First pleopod of male reaching to coxopodite of second pereiopod when abdomen is flexed; terminal elements subequal in length in most specimens, central projection slightly longer in others. Annulus prominently bi-tuberculate with tubercles widely separated (fig. 6).

Holotypic Male, Form I.—Body subovate, decidedly depressed; abdomen narrower than thorax; width of carapace (fig. 3) greater than depth in region of caudodorsal margin of cervical groove (15-11.5 mm).

Areola of medium breadth (4.2 times longer than wide) with three to four punctations at narrowest part; cephalic portion of carapace about 2.2 times as long as areola; areola about 28% of length of entire carapace.

Rostrum bearing thickened concave margins which terminate cephalad in prominent, slightly raised spines; upper surface concave and bearing setae. Acumen long with upturned tip. Subrostral ridges not prominent and visible only for a short distance in the dorsal aspect. A row of setiferous punctations located mesially along either marginal ridge.

Postorbital ridges prominent, shallow groove dorsolaterally and terminating in heavy pointed tubercles. Suborbital angle absent. Branchiostegal spine acute. Surface of carapace granulate laterally and with setiferous punctuations laterally.

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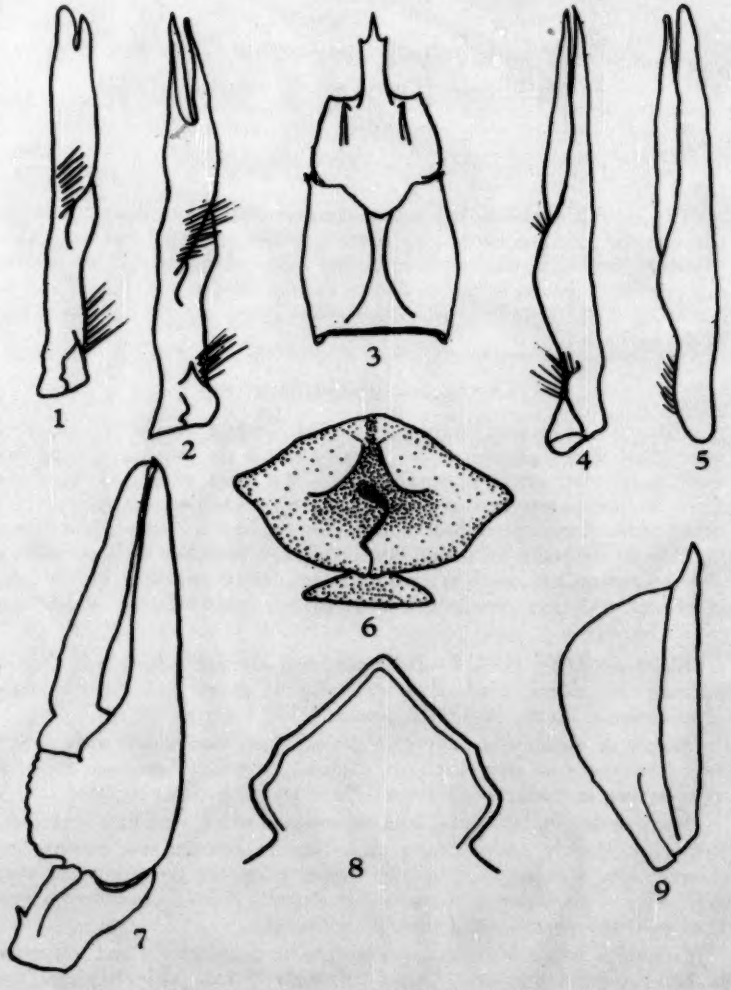
[1] This investigation was made possible in part by fellowships awarded by the John Hay Whitney Foundation (1954-54) and National Medical Fellowships, Inc. (1954-55). The funds for the latter were provided by the National Foundation for Infantile Paralysis. Dr. Horton H. Hobbs, Jr., identified the specimens as an undescribed species.

[2] This represents a part of the dissertation which was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Zoology at the University of Illinois.



Figs. 1-9.—1. Mesial view of first pleopod of morphotypic male, form II; 2. Mesial view of first pleopod of holotype; 3. Dorsal view of carapace of holotype; 4. Lateral view of first pleopod of holotype; 5. Lateral view of first pleopod of morphotypic male, form II; 6. Annulus ventralis of allotype; 7. Upper surface of chela of holotype; 8. Epistome of holotype; 9. Antennal scale of holotype.

Cephalic section of telson bispinose in each caudolateral corner.

Epistome bell-shaped and bearing no cephalomedian projection (fig. 8).

Antennules of usual form.

One antenna of holotype broken; unbroken one about equal in length to the total length of the crayfish. Antennal scales extending about to tip of rostrum; rather long and bearing a strong acute spine distally (fig. 9); mesial margin of lamellar portion semisquare.

Chelae slightly depressed distally and inflated proximally; setiferous punctations covering all surfaces (fig. 7). Both fingers terminating in short incurved corneous tips; tip of immovable finger overhanging that of movable finger; inner margin of palm with two rows of tubercles. Fingers slightly gaping throughout their entire length, the gap somewhat wider at the base. Outer margin of immovable finger bearing a keel. Opposable margins of fingers bearing heavy tubercles with those of the immovable finger being larger.

Hooks on ischiopodites of third pereiopods only.

First pleopod extending to middle of coxopodite of second pereiopod when abdomen is flexed (figs. 2, 4). Tip terminating in two distinct, subequal rami which are separated for a short distance; central projection slightly longer; rami divergent (central projection directed cephalodistad and mesial process caudodistad). Central projection corneous, almost straight and tapering sharply distally. Mesial process non-corneous and turning laterad.

Morphotypic Male, Form II.—Similar to the holotype male except for the following: Chelae proportionately smaller and less inflated; hooks on ischiopodites of third pereiopods considerably smaller; first plepods lacking corneous tips on rami, both mesial and central processes blunter and thicker (figs. 1, 5).

Allotypic Female.—Differs from the holotypic male in that the tuberculation of the chelae is more pronounced. The dorsolateral surface of the postorbital ridge is more deeply grooved. Epistome bearing a small cephalomedian spine and somewhat subquadrate.

Measurements (in millimeters).

	Holotype	Allotype	Morphotype
Carapace			
height	11.7	13.6	16.3
width	14.2	16.4	19.9
length	28.3	34.3	41.9
Areola			
length	8.0	9.2	12.8
width	1.7	1.8	2.2
Rostrum			
length	7.6	8.5	10.6
width	3.9	4.6	5.6
Abdomen			
length	30.5	32.3	39.3
Right chela			
length of inner margin of palm	6.3	5.5	9.3
width of palm	9.1	6.7	11.9
length of outer margin of hand	24.1	21.2	32.8
length of dactyl	14.9	13.5	20.6

Annulus ventralis longest in the transverse axis; prominently bi-tuberculate with the tubercles widely separated. Sinus originates mediodextrad, traverses sinistrad across the median line; here it turns caudodextrad to the median line and follows sinuously to the caudomedian margin of the annulus.

Type Locality.—The holotype and the allotypic female were collected from Cypress Creek, 3¼ mi. south of Mt. Pleasant, Union County, Illinois. These specimens were collected with a minnow seine Sept. 30, 1954. The temperature of the air was 22°C. The water was turbid; the stream had a rocky bottom and it varied in depth from 2-3½ feet; it was about 18 feet wide at this location. The chemical condition of the water was as follows: pH 7.2, CO_2 16 ppm, oxygen 4.64 ppm, and methyl orange alkalinity 153 ppm. The morphotypic male was collected by seine July 13, 1954 from the Cache River, 1¼ mi. NW Mt. Pleasant, Union County, Illinois. The air temperature was 33°C., while the temperature of the water was 24°C. The stream was about twenty feet wide at this locality and the water ranged from 1½-3 feet in depth. The bottom of the stream was rocky and some crayfish were observed hiding under the rocks. The pH was 7.4, dissolved carbon dioxide 10 ppm, dissolved oxygen 5.27 ppm, and the total alkalinity 155 ppm.

Specimens Examined.—One hundred twelve specimens of this species were collected during the previously mentioned investigation. These specimens were collected from fifteen stations in the following counties in southern Illinois. ALEXANDER Co.: Sandy Creek, ½ mi. NW Diswood; GALLATIN Co.: Cypress Ditch, ½ mi. NW Junction; HARDIN Co.: Hick's Branch, 4 mi. NE Eichorn; a branch of Harris Creek, 5½ mi. N Elizabeth; POPE Co.: Bay Creek, 1½ mi. W Homberg; Gibbons Creek, 1 mi. NW Herod; a branch of Robnett Creek, ½ mi. W Rose Bud; Hobb's Creek, 4¼ mi. SE Hartsville; Hunting Branch, 4¼ mi. NW Eddyville; Hayes Creek, 1 mi. E Glendale; UNION Co.: Cache River, 1¼ mi. NW Mt. Pleasant; Lick Creek, 2¼ mi. NW Lick Creek; Big Creek 3¼ mi. E Balcom; Cypress Creek, 3¼ mi. S Mt. Pleasant.

Disposition of Types.—The holotypic male, form I, and the allotypic female (USNM nos. 97997 and 97998 respectively) and the morphotypic male, form II (USNM no. 91661) are deposited in the United States National Museum. Three paratypes (1 form I male, 1 form II male, and 1 female) are in the personal collection of Dr. Max R. Matteson of the University of Illinois. Likewise, paratypes consisting of the same three forms are in the personal collections of both Dr. Horton H. Hobbs, Jr. of the University of Virginia at Charlottesville, Virginia and Dr. Troy C. Dorris of Quincy College, Quincy, Illinois. The remainder of the specimens are in the research collections which are at present retained by the writer for the University of Illinois.

Relationships—*Orconectes illinoiensis* probably has its closest affinities with *O. p. propinquus* (Girard, 1852) and *O. propinquus jeffersonii* (Rhoades, 1944). The annuli ventrali of the females and the copulatory appendages of the males reflect this similarity to a marked degree. *Orconectes illinoiensis* is readily distinguishable from *O. p. propinquus* by the lack of a median carina, the more setiform and divergent gonopods, the narrower areola, and the rostrum with concave sides. The annulus ventralis of *Orconectes p. propinquus* is bi-tuberculate with the tubercles depressed and narrowly separated, while the tubercles of the annulus ventralis of *O. illinoiensis* are raised and widely separated. *Orconectes illinoiensis* differs from *O. p. jeffersonii* in that it has a narrower

rostrum which has concave sides, and the tubercles of the annulus ventralis are less prominent. This species exhibits a distant relationship with *Orconectes virginiensis* (Hobbs, 1951).

REFERENCES

BROWN, P. L. 1955—The Biology of the Crayfishes of Central and Southeastern Illinois. Unpublished Ph.D. Thesis Univ. of Illinois.

GIRARD, C. 1852—A revision of the North American *Astaci* with observations on their habits and geographical distribution. Proc. Acad. Nat. Sci. Philadelphia 6:87-91.

HOBBS, H. H., JR. 1951—A New Crayfish of the Genus *Orconectes* from Southeastern Virginia (*Decapoda, Astacidae*). Va. J. Sci. 2:122-128.

RHOADES, R. 1944—The Crayfishes of Kentucky. Amer. Midl. Nat. 31:11-149.

The Ants of Ramsey County, North Dakota[1]

Paul B. Kannowski

University of Michigan, Ann Arbor

This study is based upon approximately 300 collections of ants made during the summer and fall of 1951. Several localities were revisited on September 8, 1953 when a few additional collections were made. In addition to my own, I have attempted to include all other collections known to me, and the few published records. It was the purpose of this study to determine the kinds of ants present in the county, and to note the ecological affinities of these ants.

Acknowledgments.—I gratefully acknowledge the assistance of George C. Wheeler of the University of North Dakota, under whose direction this study was made. I also wish to acknowledge my indebtedness to Mrs. George C. Wheeler, University of North Dakota, and Marion R. Smith, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C., for assistance in the identification of the ants; to William L. Brown, Jr., Harvard University, for the identification of several species of *Formica;* to Edward O. Wilson, Harvard University, for supplying names for the species of *Lasius;* to Louise M. Russell, U. S. Bureau of Entomology and Plant Quarantine, Washington, D. C., for the identification of aphids and membracids; and to Vera Facey, University of North Dakota, and Saul Aronow, Water Resources Division of the U. S. Geological Survey, for their assistance in the preparation of this report. The ants collected in Ramsey County, North Dakota by Crystal Thompson, N. A. Wood and T. H. Hubbell in 1919, 1920, and 1921, and now in the University of Michigan Museum of Zoology, were kindly made available to me by the authorities of that institution.

Geologic and Climatic Features

Ramsey County lies in the east-central part of North Dakota. Physiographically, the county is in the Western Young Drift section of the Central Lowland province (Fenneman, 1938). The area is entirely covered by a mantle of glacial drift, deposited largely by the last Wisconsin glacier. Apparently the bedrock surface, which is the Pierre shale of Cretaceous age, is nowhere exposed. Most of the drift is derived from the underlying Pierre shale.

A variety of glacial features is present in Ramsey County. Several end moraines cross the area with a northwest-southeast trend. Because of the impermeability of the till, the depressions of the moraines are frequently occupied by marshes and lakes. Boulders are commonly found on the surface of undisturbed till but may be seen in piles on farms where they have been removed for cultivation of the land. These boulders form excellent nesting sites for certain species of ants. Much of the county is covered by thin ground moraines, and these parts are gently rolling areas with a local relief of no more than 20 to 30 feet. An outwash plain of sands and gravels begins in

[1] This paper is part of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at the University of North Dakota in 1952.

the extreme southeastern tip of the county and extends southward into Benson County. Kames and eskers, which are ice-contact features consisting of gravel, sand and silt, occur in the southwestern part of the county. At the southeastern corner is Devils Lake Mountain, a topographic "high" that is visible for many miles. It is about three miles long and trends in a northeast-southwest direction; it lies within, but everywhere rises above the North Viking moraine. Quite likely, Devils Lake Mountain owes its origin to a bedrock "high" of the underlying Pierre shale.

The soils of Ramsey County belong to the Barnes series (Walster, 1924). These soils are derived from glacial drift that has been weathered, but with very little leaching. A considerable accumulation of black organic matter has occurred in the surface soils, which are less compact in structure than the subsurface soils. The color of the surface soils is dark-brown to black; the sub-surface soils are grayish-yellow to yellowish-brown. The Barnes soils are very productive; they have a high organic content, are easily tilled, and do not crack or bake on drying.

Ramsey County lies in the Devils Lake Basin, an interior drainage basin of about 3,500 square miles (Simpson, 1912). The drainage is poorly developed; there are no permanent streams, and only two intermittent streams, Mauvais Coulee and the Sweetwater Inlet, are well defined. The Sweetwater Inlet drains the north-central part of the county through Sweetwater Lake, Dry Lake, and Twin Lakes into Lac aux Mortes, where it joins the waters of the Mauvais Coulee. The Mauvais Coulee drains from Towner County in the north through Lac aux Mortes and Lake Irvine into Devils Lake. At one time the Mauvais Coulee probably carried some glacial drainage from the northern part of the state. Now, these youthful streams carry water only during the spring run-off and after heavy rains. Marshes and lakes are abundant throughout much of the county, but many of the marshes and shallower lakes are dry in late summer.

One of the most prominent topographic features in Ramsey County is Devils Lake. The lake, which is a remnant of a once larger glacial lake, is now divided into four large bays—West, Main, East and Lamoreau—and several smaller ones. During historic time Devils Lake has been progressively drying up. West Bay is the only one that is completely dry today, while East Bay is nearly dry. The other bays are relatively shallow and all are now separated from each other. In the spring the bays may be temporarily filled with run-off waters. Although Devils Lake lies in the Devils Lake Basin, very little of the drainage of the basin ever enters the lake. Mauvais Coulee is the only present inlet into Devils Lake, and there is no outlet.

The exposed bottom sediments of Devils Lake consist of silt, clay and reworked till, the shore features—beaches, spits and bars—of sand and gravel. In some places the uppermost shore lines are marked by numerous boulders, especially along the southeast shores. These rock ridges were probably formed by ice jams in the lake during late winter or early spring.

According to Bavendick (1946) the climate of Ramsey County is subhumid, with long cold winters and short warm summers. With a short growing season of approximately 130 days, abundant precipitation is necessary during the late spring and early summer months. Weather records at the city of

Devils Lake show an average annual precipitation of 18.05 inches, most of which falls as light rains from May through August. The average annual snowfall is between 30 and 35 inches, most of it occurring from December through February. The mean annual temperature is 37°F. Clear to partly cloudy skies are common, especially in the summer. The prevailing winds are northwesterly.

ECOLOGICAL DISTRIBUTION

A number of collecting stations that were deemed representative of the various ecologic communities were selected for intensive study. Since the larger part of the county is prairie, most of these stations were located in grassland areas. The localities for these stations are as follows:

1) Section 12, Freshwater Township
2) Section 28, Stevens Township
3) Section 12, Township 152N, Range 63W
4) Section 23, Nixon Township
5) Section 36, Ontario Township
6) Section 26, Freshwater Township
7) Section 2, Township 151N, Range 62W
8) Section 5, Township 151N, Range 62W
9) Section 18, Township 153N, Range 65W
10) Section 13, Township 153N, Range 65W
11) Section 32, Freshwater Township
12) Section 14, Morris Township
13) Section 36, Triumph Township
14) Section 2, Highland Center Township
15) Section 22, Fancher Township
16) Section 22, Klingstrup Township
17) Section 18, DeGroat Township
18) Section 16, Township 153N, Range 64W
19) Camp Grafton Military Reservation

In the remainder of this report the localities will be referred to only by the station number.

According to Clements and Shelford (1939), a large part of central and western North America belongs to the North American grasslands biome. This biome is divisible into a number of associations which are distinguished by the prevailing dominant grasses. Two of these associations, the mixed prairie and the true prairie, occur in North Dakota. The mixed prairie lies mainly west of the 100th meridian and includes the more western part of the state. The true prairie occurs in the Red River Valley in extreme eastern North Dakota. A broad ecotone connects the two associations.

Carpenter (1940), in a study of the grassland biome, considers that all three of the grassland associations occur in North Dakota: 1) the tall grass prairie in central and eastern North Dakota; 2) the mixed grass prairie-plains passing diagonally thru the state from the northwestern corner thru the south-central part; 3) the short grass plains in the southwestern corner of the state. Ramsey County would be considered to be in the northern faciation of the tall grass prairie.

The differences between the vegetation of the Red River Valley and of the low plains of east central North Dakota are too great to permit these areas being placed in the same category. There is a signifiacnt difference in climatic and especially edaphic conditions in these two regions of the state, and these factors are responsible in large part for the vegetational differences.

Most, if not all, of Ramsey County probably lies in the ecotone between the true and mixed prairies. Plants which are characteristic of the true prairie

were found to be largely restricted to moist lowland areas. The mid and short grasses of the mixed prairie occupy most of the well drained locations.

For the purposes of this study, four sub-divisions of the prairie were made. The four communities thus delimited are 1) mixed grass prairie, 2) tall grass prairie, 3) sand dunes and beaches, and 4) dry lake bed.

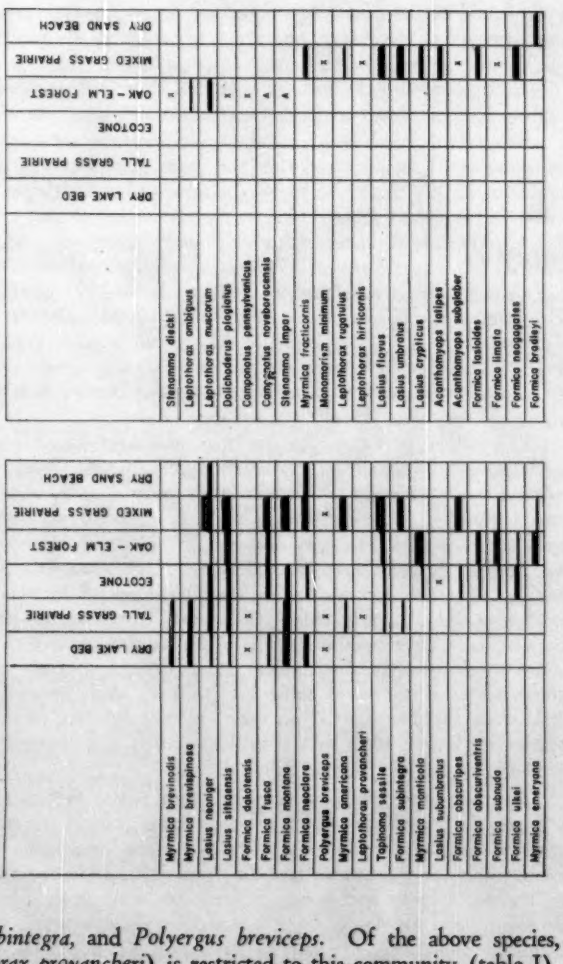
The *mixed grass prairie* is the most common community in this region. It occupies the well-drained clay and loam soils, but due to intensive cultivation it is largely restricted to the hilltops and steep slopes. Collections were made in the mixed grass prairie at the following stations: 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16. Short and mid grasses such as *Bouteloua gracilis* (H. B. K.) Lag., *Koeleria cristata* (L.) Pers., *Andropogon scoparius* Michx., and *Muhlenbergia cuspidata* (Torr.) Rydb. are characteristic on these areas. Common herbs include *Aster ericoides* L., *A. ptarmicoides* (Nees) T. & G., *Chrysopsis villosa* (Pursh.) Nutt., *Gaillardia aristata* Pursh., *Liatris punctata* Hook., and *Petalostemum purpureum* (Vent.) Rydb. In protected areas on slopes shrubs such as *Eleagnus commutata* Bernh., *Rosa* spp., and *Symphoricarpos occidentalis* Hook. are common.

The following twenty-four species of ants were found to occur on the mixed grass prairie: *Myrmica americana, M. emeryana, M. fracticornis, Monomorium minimum, Leptothorax hirticornis, L. rugatulus, Tapinoma sessile, Lasius crypticus, L. flavus, L. neoniger, L. sitkaensis, L. umbratus, Acanthomyops latipes, A. subglaber, Formica fusca, F. lasioides, F. limata, F. montana, F. neoclara, F. neogagates, F. obscuripes, F. subintegra, F. subnuda* and *Polyergus breviceps*. Perhaps *Leptothorax muscorum* should be added to this list, for a single worker was collected in this community. However, its nest, which was not located, may have been in a tree in the nearby roadside. The abundance of these species in this community and frequency of their occurrence in other communities is shown in table I. Most of these species find the optimum conditions for the success of their colonies in this community, but several species are known from so few collections that it is impossible to state whether or not they are restricted to it.

The *tall grass prairie* occurs in places where moisture is more abundant than on the mixed grass hills. Grassy areas around the borders of lakes and marshes, and natural drainage paths in the morainal areas, have a greener and more luxuriant vegetation than do drier sites. This community is uncommon in Ramsey County and occurs in areas of small size. The collecting stations representing it are 1, 10, 14, 15, and 17. Grasses which were found at these localities include *Agropyron trachycaulum* (Link) Malte., *Bouteloua curtipendula* (Michx.) Torr., *Calamagrostis inexpansa* A. Gray, *Panicum virgatum* L., *Spartina pectinata* Link, *Agropyron cristatum* (L.) Gaertn., *A. repens* (L.) Beauv., *Bromus inermis* Leyss., and *Poa pratensis* L. The last four species are introduced grasses which are locally abundant in this community. Herbs found in these localities include *Allium stellatum* Fraser, *Aster laevis* L., *Campanula rotundifolia* L., *Gentiana andrewsii* Griseb., *Liatris scariosa* (L.) Willd., *Lilium philadelphicum* L., and *Monarda fistulosa* L.

Eleven species of ants were found nesting in the tall grass prairie. They are *Myrmica americana, M. brevinodis, M. brevispinosa, Leptothorax provancheri, Tapinoma sessile, Lasius neoniger, L. sitkaensis, Formica dakotensis,*

TABLE 1.—The distribution and relative abundance of ant colonies in six communities occurring in Ramsey County, North Dakota. The estimate of abundance is based upon the number of colonies of each species collected and observed in each community, and is graphically shown by a 1 to 5 scale of widths of the black bars in the columns. The widest bar stands for maximum abundance of each individual species, but for different species equal widths of bar do not necessarily indicate equal abundance. A—*Camponotus noveboracensis* and *Stenamma impar* have not yet been taken in the Oak-elm Forest, but may be found there since they do occur in the Aspen Community (not here shown). X—species which have been taken in the community but on too few occasions to permit an estimate of their abundance to be made.



F. montana, F. subintegra, and *Polyergus breviceps.* Of the above species, only one (*Leptothorax provancheri*) is restricted to this community (table I). However, intensive searching for *provancheri* may show that it occurs in the same communities as *Myrmica brevinodis.*

The *sandy beaches and dunes* of Devils Lake support a distinct community in which the vegetation is sparse and consists largely of grasses and sagebrush. *Artemisia frigida* Willd., *Agropyron repens* (L.) Beauv., *Distichlis stricta* (Torr.) Rydb., *Eragrostis megastachya* (Koel.) Link, and *Sporobolus cryptandrus* (Torr.) A. Gray are plants typical of these areas. The sand is fine grained and loose, and in several localities is formed into small dunes. Where vegetation has stabilized these dry sandy areas, mixed grass prairie develops. Collections were made on these beaches at three localities:

3, 9, and 10. In addition, several collections of ants were made on the beach of Sweetwater Lake (Station 1) where there was no vegetation in the vicinity of the ant nests. This beach, however, is moist, while the beaches of Devils Lake are high and dry and at a considerable distance from the present bodies of water, having been formed at a time when the lake levels were much higher.

Only three species of ants were found on the sand beaches and dunes of Devils Lake. *Lasius neoniger* is very common in open, sunny areas. *Formica neoclara* is common in sandy terrain, but also occurs in the silt and clay soil of the dry lake bed. *Formica bradleyi* is the only ant restricted to this community, and it was collected at only one station. *Myrmica brevispinosa* and *Lasius neoniger* were the only species to be found nesting in the beach at Sweetwater Lake.

The recession of the water level of Devils Lake has exposed large areas of lake bed. Those areas which became dry in the distant past are now occupied by the prairie communities described above or by the deciduous forest community. The areas which have been exposed in the last thirty to forty years, and which are covered with several inches or more of water after the spring run-off and after heavy rains, are occupied by pioneer grassland communities. The salt flats nearest the standing water usually contain a dense population of a single plant, *Salicornia rubra* A. Nels. However, these flats appear to be too moist to permit colonization by ants. The *Salicornia community* is succeeded by a community of sparse to moderately abundant vegetation consisting of two species of grasses (*Hordeum jubatum* L. and *Calamagrostis inexpansa* A. Gray), and several weedy herbs. *Hordeum jubatum* is the most abundant plant species in this *dry lake bed community*. The silt and clay soil is usually fairly moist throughout the year. Stones and boulders were absent in the area studied (Station 18). Nine species of ants (*Myrmica brevinodis, M. brevispinosa, Lasius neoniger, L. sitkaensis, Formica dakotensis, F. fusca, F. montana, F. neoclara,* and *Polyergus breviceps*) were living in this community. All of these ants, except *Lasius neoniger,* had similar nests, i.e., all lived in mounds of soil which were a foot or more in height. *Hordeum jubatum* was usually found growing on the mounds. The presence of *Formica dakotensis, F. fusca, F. montana,* and *Polyergus breviceps* in mounds is not unusual because they were found living in mounds in other areas. *Lasius sitkaensis* was occasionally found to occupy mounds in other communities. However, it is unusual for *Formica neoclara* and the two species of *Myrmica* to live in mounds. The only evident explanation for their doing so here lies in the annual rise of the water level after the spring run-off. Only those species which live in nests which are partly above the water level can survive. This also explains why *Lasius neoniger* is absent from all but the outermost part of the community; this ant does not build its nests above the ground surface, and would thus be flooded out periodically. *Neoniger* nests, however, do occur in abundance on the periphery of this community.

It is obvious from an examination of the dry lake bed that the mounds of soil were all made by ants. It is unlikely that the two species of *Myrmica* and possibly *Formica neoclara* as well constructed their own mound nests. It is more likely that the colony founding females of these species started their colonies in abandoned *Formica* and *Polyergus* nests. Because *Formica dako-*

tensis and *Polyergus breviceps* are parasitic on colonies of other species of *Formica*, all the mounds may have been originally constructed by *F. fusca* and *F. montana*.

According to Braun (1950) the deciduous forest, which is largely confined to stream valleys and protected slopes in the prairie region, is a part of the oak-hickory forest region. Bur oak is the only oak present, and hickories are absent. The *deciduous forest association* is poorly represented in Ramsey County. Naturally forested areas are found almost exclusively around the borders of lakes; there are no forest-bordered streams in the county. The deciduous forest association is represented by three communities: 1) oak-elm forest; 2) aspen groves; 3) "tree-claims".

The *oak-elm forest*, the largest natural forest community in the county, occurs most extensively bordering Devils Lake and Sweetwater Lake, with the densest growth always on the southeast side of the lakes. The oak-elm forest is a post-climax community in Ramsey County; rainfall is insufficient in this region for its spread. Collections were made in it at the following stations: 6, 8, 10, and 19. Characteristic trees of this forest are *Acer Negundo* L., *Celtis occidentalis* L., *Fraxinus pennsylvanica* var. *subintegerrima* (Vahl) Fern., *Quercus macrocarpa* Michx., *Tilia americana* L., and *Ulmus americana* L. *Amelanchier alnifolia* Nutt., *Prunus virginiana* L., and *Ribes* spp. are the most common shrubs. Common herbs include *Arisaema atrorubens* (Ait.) Blume., *Aster laevis* L., *Carex* spp., *Hydrophyllum virginianum* L., *Urtica procera* Muhl., and *Viola* spp.

Thirteen species of ants occur in the oak-elm forests (Table 1). They are *Myrmica emeryana, M. monticola, Stenamma diecki, Leptothorax ambiguus, L. muscorum, Dolichoderus plagiatus, Tapinoma sessile, Lasius neoniger, L. sitkaensis, Formica fusca, F. obscuriventris, F. subnuda,* and *F. ulkei*. Perhaps none of the above ants is restricted to this community. *Stenamma diecki* and *Dolichoderus plagiatus* are known only from a few specimens from one locality. Additional collecting might show these to occur in other forest communities. *Formica ulkei* is considered a member of this community although it prefers to nest in sunny openings in the woods or in the ecotone between forest and prairie. It may also occur in other forest communities. *Formica obscuriventris* is typical of the oak-elm forests. It has not been collected in other forest communities, and does not occur in the prairie communities, but does occur in the forest ecotone. *Leptothorax ambiguus* and *L. muscorum* are present in other forest communities, but no colonies were found in the prairie. The remaining species occur in both prairie and forest communities. It is of interest to note that no carpenter ants (*Camponotus* spp.) were collected in the oak-elm forests in spite of intensive searching. The *Camponotus pennsylvanicus* collection made by Wood in 1921 probably came from this community.

There are a number of *aspen groves* (*Populus tremuloides* Michx.) in the county, especially around Devils Lake. All of the groves seen were small, rarely more than 30 to 50 feet in diameter. Large areas of aspen forest occur south and west of Devils Lake in Benson County, but none of these forests extends into Ramsey County. Ants were collected in aspen groves at Stations 10 and 19. *Myrmica emeryana, Stenamma impar, Leptothorax ambiguus, L. muscorum,* and *Camponotus noveboracensis* were collected in this com-

munity. Additional collecting may increase this list. *Myrmica emeryana* lives in both forest and prairie communities; the other species are exclusively forest dwellers in Ramsey County. *Stenamma impar* and *Camponotus noveboracensis* were each found only once, and may occur in other forest communities.

Man-made "*tree-claims*" are a third forest community. "Tree-claims" are groves of trees—usually box-elder (*Acer Negundo* L.,), cottonwood (*Populus deltoides* Marsh.) or willow (*Salix* spp.)—which were planted on the prairies by settlers to fulfill government requirements for settlement of the land. These groves are now characterized by tall trees, few shrubs and herbs, and a floor which may be barren or covered by introduced grasses (*Agropyron repens* (L.) Beauv., *Bromus inermis* Leyss., and *Poa pretensis* L.). These trees do not spread onto the prairie, and they seldom reproduce themselves. A "tree-claim" at Station 2 was studied. *Myrmica monticola* was the most abundant ant in this woods, while *M. emeryana* was the only other member of this genus to occur here. *Lasius sitkaensis* was rather common. All were found under bark and/or in decaying wood. A single colony of *Formica subnuda* and its slave, *F. fusca,* was found in the grass at the edge of this woods. The study of additional "tree-claims" may add several species to the list, but ants which live in the floor of the oak-elm and the aspen forests would not find suitable conditions in the floor of a "tree-claim." It is surprising that no carpenter ants were found in this community, since there are numerous nesting sites available.

Three ant species—*Lasius neoniger, L. sitkaensis,* and *Formica fusca*—occur in most of the plant communities in Ramsey County. These ants are tolerant of a wide range of conditions, and are capable of existing in abundance in diverse habitats and plant communities. They merit the term "common species."

Annotated List of Species

All collections were identified with the aid of the keys in Creighton (1950). In certain difficult groups determinations were later verified by specialists. The taxonomic treatment generally follows that of Creighton except where more recent studies have been made. The collections in the University of Michigan Museum of Zoology are designated by the abbreviation (UMMZ).

Subfamily MYRMICINAE

1. MYRMICA AMERICANA Weber

There appear to be two different species under the name *Myrmica americana* on the basis of the male caste. All of the workers of the Ramsey County collections seem to be *americana,* but, in the several cases in which males were found in the nests, the males do not fit the description of this species. A single male, collected on September 8, 1953, and unassociated with workers or females, agrees with Weber's description of *americana.* Certain correlation of this latter form of male with workers and females is necessary for the determination of these collections.

Americana is common on the prairies (stations 3, 7, 9, 12), where it nests in well-drained clay or sandy loam soil. Nests were usually found at the roots of plants. However, one nest was beneath a small stone in the soil, and another was in a small mound of loose soil. *Americana* workers plundered nests of *Lasius flavus* and *Lasius umbratus* which I had opened. Alate forms were found in the nests on August 1 and 9. A male was found on a grass stem on September 8, 1953. This species is recorded by Weber (1948) from Devils Lake.

2. MYRMICA BREVINODIS Emery

This species is uncommon but widely distributed in the county (stations 14, 15, 17, 18). It was found only in rather moist clay or loam soils. Its nests were usually located in the soil beneath large stones, but once it was found nesting in a large mound of loose soil built around a clump of grass (*Hordeum jubatum*) in the dry bed of Devils Lake. Alate forms were collected from nests on August 17 and 18, 1951 and on September 8, 1953. An alate female was found crawling on a grass culm on September 17, 1951, indicating that the mating flight had recently taken place. Six workers of *Leptothorax provancheri* were found in a part of one *brevinodis* nest; the relationship of these two species is discussed under *provancheri.*

3. MYRMICA BREVISPINOSA Wheeler

This uncommon ant apparently prefers a rather moist nesting site in sand or clay loam (stations 1, 17, 18). On the sand beach of Sweetwater Lake its nests consist of a small crater of sand surrounding the single central opening. One nest was found in horse dung and in the soil at the roots of a grass (*Agropyron cristatum*) beneath the dung. A third type of nest was a large mound of loose soil built around the roots of a grass (*Hordeum jubatum*). This type was found only on the dry bed of Devils Lake. Alate forms were found in the nest on September 17, 1951.

Myrmica brevispinosa is recorded from Devils Lake by Weber (1950). This species has also been collected at Devils Lake Narrows (C. Thompson, UMMZ), and the Biological Station near Devils Lake, (N. A. Wood, UMMZ).

Although I have not seen any of the types, I have examined many nest series of *brevispinosa* from Washington, Montana, North Dakota, and Michigan. This study leads me to suggest that the form *discontinua,* which Weber (1939) described as a subspecies of *brevinodis,* and which Creighton (*op. cit.,*) treats as a subspecies of *brevispinosa,* may be without validity. All of the characters which Weber uses in distinguishing *discontinua* from *brevispinosa* are variable in any large nest series. Indeed, Weber notes this variation with nest series in his discussion of *brevispinosa* (1950). Because these characters are not constant, it is likely that *discontinua* Weber should be placed in the synonymy of *Myrmica brevispinosa.*

4. MYRMICA EMERYANA Forel

Myrmica emeryana is abundant in the woods (stations 2, 3, 6, 7, 8, 9,

10, 13, 15, 19), where it forms moderate sized colonies in the more moist locations. The population size of mature colonies varies roughly between 150 and 500 workers. Nests were collected from leaf litter, in the soil beneath a log, under bark, and in cavities in both soft and hard wood. One collection was taken from beneath a stone in grass at the edge of a woods. Prairie nests were usually found under stones; however, one colony was found nesting at the roots of a grass (*Calamagrostis inexpansa*). Alate females and males were found in the nests between July 29 and August 23, 1951. An alate female, collected on September 8, 1953, had already started a nest in the edge of a nest of *Acanthomyops latipes* which was under a stone on a dry hillside. N. A. Wood collected a series of *M. emeryana* at the U. N. D. Biological Station (UMMZ).

5. MYRMICA FRACTICORNIS Emery

A single nest of this form was found August 18, in dry cow dung; males were present in it. All other collections are represented by isolated workers whose nests were not located (stations 12, 14, 15, 16). This species is recorded from Edmore by Weber (1948).

6. MYRMICA MONTICOLA Wheeler

Myrmica monticola is abundant in certain woodland stations (stations 1, 2, 6, 8), where it competes with *M. emeryana* for nesting sites. This species is evidently not entirely restricted to woodlands as Weber (1948, as *M. sabuleti nearctica*) claimed, for one colony was collected beneath a stone at a prairie station. Woodland nests were located in soil next to a decaying stump, in decaying stumps, beneath bark of dead trees and logs, and under a stone in the floor of the woods. Alate forms were found in the nests on August 3 and 9. One nest contained several dealated females.

7. STENAMMA DIECKI Emery

No nests of this hypogaeic species were found. Several specimens were collected by drying leaf-mold in a Berlese funnel (station 8).

8. STENAMMA IMPAR Forel

A single dealate female of *impar* was collected by drying forest leaf-mold in a Berlese funnel (station 19).

MONOMORIUM MINIMUM (Buckley)

A single nest was collected on a sunny, well-drained slope of Devils Lake Mountain (station 7.) The nest was shallow, extending only five inches into the soil, and opened to the surface by a single, small opening surrounded by a small crater of loose soil. Isolated workers, whose nest was not located, represent the only other collection of this species.

10. LEPTOTHORAX AMBIGUUS Emery

Only one colony of *ambiguus* was found; this was nesting in a rotten root of a decaying stump, about 16 to 18 inches below the soil surface. The

workers were very timid, although none feigned death. This was the largest *Leptothorax* colony collected; it contained larvae (recorded by Wheeler and Wheeler, 1955), pupae, workers, alate males and females when collected on August 8. The population of this colony was well over 1000 individuals. Other collections were made by drying leaf-mold in a Berlese funnel. *Leptothorax ambiguus* is apparently restricted to woodlands in Ramsey County (stations 8, 10). It has not previously been recorded from North Dakota.

Recently, I have seen a series of workers from Billings County collected "on a butte south of Peaceful Valley Ranch, Medora" (C. Thompson, UMMZ). This collection is significant in that it extends the range into southwestern North Dakota, and secondly in that the colony was nesting in a grassland community. We need to know more of the habits of this ant in North Dakota in order to interpret the ecological differences in various areas of the state.

11. LEPTOTHORAX HIRTICORNIS Emery

This rare ant lives as an inquiline in the thatch of *Formica obscuripes* nests. One nest contained numerous alate females on July 1 (stations 4, 7).

12. LEPTOTHORAX MUSCORUM (Nylander)

Abundant in woodlands (stations 8, 9, 10, 19), *muscorum* forms small colonies in galleries and chambers in the wood of decaying stumps and logs, and beneath the bark of fallen trees. Two nest queens were found in one colony. This ant has been known by the name *L. canadensis* Provancher, however, Brown (1955) has shown that *canadensis* is a synonym of *muscorum*.

13. LEPTOTHORAX PROVANCHERI Emery

A single collection of six workers of *provancheri* was taken in a nest of *Myrmica brevinodis* (station 17). Both nests were in rather moist clay soil beneath a large stone. The *provancheri* workers were found in chambers one or two inches below the surface of the soil. The small size of the passageways of the *provancheri* nest prevented the entrance of the *Myrmica* workers, but the *provancheri* workers had the run of the *Myrmica* nest. The two species apparently live quite amiably together. This is the first record for North Dakota.

14. LEPTOTHORAX RUGATULUS Emery

Only one nest of this species was found; it was located in chambers in the soil at the roots of a clump of grass (*Bouteloua gracilis*). The nest entrance was a tiny hole in the soil in the center of this clump. The workers were very active when I opened the nest and concealed themselves quickly under blades of grass, etc. Other collections consist only of isolated workers whose nests were not located (stations 12, 15, 16). *Rugatulus* apparently prefers to nest in sandy loam in well drained locations.

These ants key out to *L. rugatulus brunnescens* Wheeler in Creighton (1950). That author (*op. cit.*) considers what *brunnescens* may eventually

prove to be a separate species. I have not examined the types of these forms, and am uncertain of the exact status of *brunnescens,* but, these Ramsey County specimens show enough variation to cast doubt on its validity. Wheeler and Wheeler (1944) have recorded this species from North Dakota as *L. rugatulus dakotensis* G. C. and E. W. Wheeler, which Creighton (*op. cit.*) has synonymized with *brunnescens.*

Subfamily DOLICHODERINAE

15. DOLICHODERUS PLAGIATUS Mayr

Nests of this species were not found; the collections consist only of stray workers (station 8).

16. TAPINOMA SESSILE (Say)

This ant is common and widely distributed throughout the country (stations 3, 5, 6, 7, 8, 9, 11, 12, 15, 19). It was found in a variety of nest types, but most commonly beneath stones. It was also frequently found in and beneath dry horse and cow dung. In woods *sessile* was found in debris at the base of stumps, in decaying logs, and under bark. Its nests were frequently built in close association with nests of *Acanthomyops latipes* and *Lasius sitkaensis.* None of these species showed any hostility toward the *sessile* workers in their nests. Alates were collected on June 27 and July 5.

Subfamily FORMICINAE

17. CAMPONOTUS NOVEBORACENSIS (Fitch)

It is remarkable that members of the genus *Camponotus,* which are relatively common in woodlands throughout the remainder of North Dakota, should be rare in Ramsey County. Nevertheless, despite a thorough search, I was able to locate only one colony of *C. noveboracensis;* no other ants of this genus were seen in the summer of 1951. The colony was a small one, nesting in chambers in rather soft wood at the base of a small decaying stump in an aspen grove (station 10). Alate females were present in the nest on September 15.

18. CAMPONOTUS PENNSYLVANICUS (DeGeer)

No nests of this species were found during 1951, but a sample of a populous colony was collected by N. A. Wood at the University of North Dakota Biological Station near Devils Lake on May 10, 1921. According to the collector's notes, "this lot was in an old hollow stick of wood at the Biological Station. The colony, which had large chambers, was in a bur oak tree". Alate males and females are present in the collection.

19. LASIUS FLAVUS (Fabricius)

Lasius flavus is a characteristic ant of the prairie. In Ramsey County it is widely distributed but nowhere common (stations 5, 7, 11, 12, 14, 15, 16). The nests of this species are usually situated in soil under partly buried stones, but several were found in the soil beneath horse and cow dung. Workers of

flavus were observed tending aphids on the roots of *Bouteloua gracilis*. Males and females were present in nests on August 8, 9, and 17.

20. LASIUS NEONIGER Emery

Lasius neoniger is a common and conspicuous ant of the prairies, and also occurs in dry, open, sparsely vegetated areas in woods (stations 1, 3, 4, 9, 10, 11, 16, 17, 18, 19). The most noticeable feature of its nests is the circular crater of soil, from ½ to almost 1½ inches high, and from 2½ to five inches in diameter, which surrounds the entrances. This crater is formed of soil excavated from the nest chambers, and once made is usually not added to until wind or rain causes the passageways of the nest to be blocked with soil. Then the ants clean out the nest and the crater is rebuilt. Except at the time of the mating flights, there is only a single central opening within a crater, but during the mating period the number of openings may be increased, and the crater may lose its characteristic shape. One nest was found in the soil under a partly buried stone. Males were collected in a nest on August 8; in another females were found on September 17.

Lasius neoniger has been collected at the U. N. D. Biological Station (N. A. Wood, C. Thompson, UMMZ), Devils Lake Narrows and Odessa Narrows (both C. Thompson, UMMZ).

21. LASIUS SITKAENSIS Pergande

This species is common in both forest and prairie communities (stations 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 18, 19). In the forest communities I have found it nesting in chambers under the bark and in the decaying wood of rotting stumps and logs of various kinds and sizes. One colony occupied several chambers between leaves in the leaf litter of a forest floor, but these chambers may have represented only a part of the nest. In the prairie communities the nests of this species are usually in the soil beneath partly buried stones, or in mounds of soil. One collection was made from a pile of dirt lying on top of grass, but the ants taken here probably represented only a portion of the colony. The soil beneath dry cow dung was the site for another colony. Three colonies (from station No. 2) are recorded as having crater nests. Workers of this species were found tending aphids (*Macrosiphum ambrosiae* (Thos.)) on the stems and leaves of marsh elder (*Iva xanthifolia* Nutt.), and in two nests which were beneath stones the ants were tending aphids (*Trama* sp.) on grass roots. Alate females and males were collected on August 8, 9, 17 and September 17.

Lasius sitkaensis was collected at Sweetwater Lake (C. Thompson, UMMZ) and Devils Lake (T. H. Hubbell, UMMZ), and has been recorded from station No. 12 by Wilson (1955); that author has referred to the other collections here listed (*op. cit.*) but without definite mention of locality.

22. LASIUS SUBUMBRATUS Viereck

A single worker of this species was found in the soil beneath a board (station 1). A collection of *subumbratus* from Devils Lake (C. Thompson, UMMZ) is recorded by Wilson (*op. cit.*).

23. LASIUS UMBRATUS (Nylander)

Several types of nests of this species were found on the prairie (stations 3, 5, 7, 9, 11). These nests were located in the soil under partly buried stones; in the soil beneath dry cow dung; in large mounds of soil; and in chambers in loose soil at the roots of grass. Workers were found tending aphids (*Tetraneura* sp.) at the roots of grass. Alate forms were collected in a nest on September 8, 1953.

In spite of much collecting in wooded areas in Ramsey County, no specimens of this species were found in the forest communities. Apparently *umbratus* is restricted to the prairie in this part of North Dakota.

24. LASIUS CRYPTICUS Wilson

This ant is found only on the prairie, especially in rather dry sites (stations 7, 13, 15). Most of the time it was found nesting in the soil under some object, usually a stone. One colony occupied chambers in the soil in an area of dead grass. This species does not make craters. Males and females were found in nests on August 8, 17, and 23. These collections have been recorded by Wilson (*op. cit.*).

25. ACANTHOMYOPS LATIPES (Walsh)

The nests of *latipes* were usually found in the soil beneath partly buried stones (stations 3, 7). Nest chambers were present beneath the stones and continued down six to ten inches into the soil; subsurface passageways led away from the stones in several directions. In one colony parts of the nest were situated under three partly buried stones in an area four feet in diameter, the stones being separated by a distance of one to two feet. Each part of this nest was connected to the others by subsurface passageways. Another nest was in the soil beneath a clump of grass, close to a nest of *Tapinoma sessile*. *Tapinoma* was also found under a corner of a partly buried stone beneath which a *latipes* colony was established. The largest and most unusual nest of *latipes* was situated in the cracks of a large granitic boulder. Soil had been brought several feet to fill these cracks, and in this soil filling several wide and shallow chambers were fashioned. Each chamber had many small side pockets containing the brood, which was segregated according to the stage of development, with the large pupae assembled in the largest chambers. This nest also extended into the soil at the base of the boulder. In another *latipes* nest under a partly buried stone a colony-founding female of *Myrmica emeryana* Forel was found in a small chamber in one corner. Her presence apparently did not disturb the *latipes* workers.

26. ACANTHOMYOPS SUBGLABER (Emery)

A single nest of this species was found in small chambers in the soil beneath a partly buried stone (station 7). Several subsurface passageways led away from the nest. Workers were tending aphids which were clustered on the roots of grasses. After I had removed the stone and exposed the nest, the workers began to move the aphids from the exposed chambers to another chamber deeper in the nest.

27. FORMICA BRADLEYI Wheeler

According to Wheeler and Wheeler (1944), this ant lives only in sandy areas; therefore the sandy beaches of Devils Lake should provide suitable nesting sites. However, *bradleyi* was actually found at only one of the stations in this habitat (station 3). It was there very abundant, and dominated the ant fauna in the area. Nests of *bradleyi* were usually built at the roots of plants (grasses and sagebrush). One nest had seven openings in the sand beneath a large piece of sheet metal. Alate females were found in the nest on June 27.

28. FORMICA DAKOTENSIS Emery

A pure colony of *dakotensis* was found in a large, grass-covered mound in moist prairie and a second colony was discovered with *Formica montana* in one of the mounds on the dry lake bed (stations 14, 18). This colony, when collected on September 8, 1953, contained more than fifty alate females in the nest; no males were seen. It is unlikely that mating was still taking place so late in the year. These females had probably developed after the regular mating period or were kept from flying by the workers.

29. FORMICA FUSCA Linnaeus

Formica fusca is very common throughout the country in both woods and prairie (stations 2, 3, 4, 5, 6, 7, 8, 9, 11, 15, 16, 18, 19). In the prairie its nests were always found in mounds of soil; in the woods they were usually in contact with decaying stumps and logs. Males were present in a nest on July 26. *Fusca* workers occurred as slaves in the nests of *Formica subintegra, F. subnuda,* and as temporary hosts in the nests of *F. obscuriventris.* One colony of this species was collected at the U. N. D. Biological Station (C. Thompson, UMMZ).

In his treatment of the *fusca* complex, Creighton (*op. cit.*, pp. 519-527, 532) has proposed that the varieties *argentea, subsericea* and *subaenescens* be synonymized with *Formica fusca.* Although admitting that these forms are not identical with the typical *fusca* (p. 522), he believes that "the population forms a completely intergrading whole" (p. 521). I believe that this is an oversimplification of the case and that a satisfactory solution will not be forthcoming until we have more information of the habits of these ants in the field. Most of the Ramsey County nest series are of the form usually considered as "typical" *fusca.* The variety *argentea* Wheeler is represented by a series from a colony at Station No. 4.

30. FORMICA LASIOIDES Emery

This species was found nesting in the soil at the roots of grass (*Poa* sp.) (stations 3, 8, 11, 12, 13, 14, 16). The single opening to the nest was backed by a half-crater of soil. Workers were tending aphids (*Macrosiphum ambrosiae* (Thos.)) on the stems and leaves of marsh elder (*Iva xanthifolia*). Workers were found as slaves in a colony of *Formica subintegra.*

31. FORMICA LIMATA Wheeler

A single worker of this species was found on a dry hillside (station 7).

32. FORMICA MONTANA Emery

A characteristic ant of the prairie, *montana* may occasionally be found in open, grassy meadows in woods, or in the ecotone bordering a woods (stations 1, 3, 4, 8, 10, 12, 13, 14, 15, 17, 18). It apparently does not tolerate a great amount of shade. It usually nests in mounds of soil, but may sometimes be found in the soil beneath stones. Workers of this species were found tending aphids (*Brevicoryne symphoricarpi* (Thos.)) on *Symphoricarpos occidentalis;* others occurred as slaves in the nests of *Formica subintegra, F. subnuda,* and *Polyergus breviceps.*

This species has been collected at Devils Lake (C. Thompson, T. H. Hubbell, UMMZ) and the U. N. D. Biological Station (N. A. Wood, UMMZ).

33. FORMICA NEOCLARA Emery

This is a common ant in dry sandy areas in the county (stations 3, 8, 9, 10, 16, 18). It is a prairie form, although several collections were taken in an open, pastured woods on one of the sandy beaches of Devils Lake. Usually its nests are situated in the soil at the roots of plants. Nests were found at the roots of grasses (*Stipa* sp. and *Spartina pectinata*), white clover (*Melilotus alba*), wolfberry (*Symphoricarpos occidentalis*), rose (*Rosa* sp.), and sage (*Artemisia frigida*). On the dry bed of Devils Lake *neoclara* lives in large mounds of soil built around the culms of a grass (*Hordeum jubatum*). In one of these mounds the workers were encountered as slaves of *Polyergus breviceps. Neoclara* workers were observed tending membracids (*Publilia modesta* Uhler and *Campylenchia latipes* (Say)) on the stems of *Melilotus alba.* On August 1 alate females were coming out of a nest in the soil at the base of a wild rose (*Rosa* sp.), and climbing up the stems and branches of the shrub. Some of them flew off, but most just crawled about on the branches. No males were found in this nest. An alate female was collected by T. H. Hubbell on August 13, 1920.

Eleven collections of *neoclara* from Ramsey County are present in the Museum of Zoology at the University of Michigan. The localities of these collections are: U. N. D. Biological Station (N. A. Wood, C. Thompson); Bird Island in the Main Bay of Devils Lake (N. A. Wood, C. Thompson); Devils Lake (T. H. Hubbell), and Devils Lake Narrows (C. Thompson).

34. FORMICA NEOGAGATES Emery

Formica neogagates is widely distributed in the county (stations 4, 7, 11, 12, 14, 15, 16), but was common only at Station No. 4. There its nests were abundant in the dry sandy floor of an abandoned gravel pit. No craters or mounds were formed during dry periods. In one instance the soil around the opening had been built up into a small conical crater. Workers of this species occurred as slaves in a nest of *Formica subintegra.*

35. FORMICA OBSCURIPES Forel

A conspicuous element of the prairie ant fauna, *obscuripes* was found to nest up to the borders of woodlands, but never in the woods (stations 3, 4, 7, 8, 10, 12, 13, 15, 16). The nest was usually a large mound of soil and thatch, the latter mainly consisting of dry grass culms. One nest was built around and beneath a rock, with thatch at the base. A mound in the gravel at the side of a road consisted of soil alone; this colony was very small, and it may be that it had not developed to the stage where it used thatch. Two nests of *obscuripes* harbored colonies of *Leptothorax hirticornis* in the thatch. *Obscuripes* workers were found tending aphids (*Macrosiphum ambrosiae* (Thos.)) on marsh elder (*Iva xanthifolia*).

36. FORMICA OBSCURIVENTRIS Mayr

A form of this species was found to be rather abundant in the woodlands in Ramsey County (stations 6, 8). Nests were found in mounds of soil, in loose soil at the base of a tree, in the soil beneath a fallen log, and in the soil beneath dry cow dung in a pastured woods. Thatch, consisting of grass culms and tree twigs, was used in one nest under a log. *Formica fusca* was found as the host in one nest. *Formica obscuriventris* has not previously been recorded from North Dakota.

37. FORMICA SUBINTEGRA Emery

This is a common and conspicuous prairie ant (stations 7, 10, 12, 14, 15). Its nests were found beneath stones, in mounds, and in the soil with a crater surrounding the opening. Thatch was not found on any of the nests. Males were found in a nest on August 2. Every nest of this facultative slave-maker was found to have slaves. *Formica fusca, F. lasioides, F. montana,* and *F. neogagates* were found as slaves of *subintegra.* One nest was found to contain both *lasioides* and *montana.*

38. FORMICA SUBNUDA Emery

This species was found to nest in both woodland and prairie in Ramsey County, but was more abundant in the former (stations 2, 3, 8, 10, 15, 19). In the prairie its nests were situated under stones and in mounds of soil. The woodland nests were found under bark, in rather hard rotting wood, and in the soil beneath logs. Thatch was used in the construction of some of the woodland nests. Only four nests of this facultative slave-maker contained slaves, which were of the species *Formica fusca* and *F. montana.*

39. FORMICA ULKEI Emery

This ant is characteristic of open woodland areas and of the margin between woods and prairie (stations 8, 10, 19). Its large, dome-shaped mounds, composed of soil and thatch or of soil alone, were the largest ant mounds found in the county. They were built in sandy soil, loam, and in rich black humus, and one was constructed around a small stump. This

species was collected by N. A. Wood at the U. N. D. Biological Station near Devils Lake in 1921 (UMMZ).

40. POLYERGUS BREVICEPS Emery

The three nests of this obligatory slavemaker that were found (stations 15, 17, 18), each contained workers of *Formica montana* as slaves; one nest also contained workers of *F. neoclara*. A single dealate female was found crawling on the ground on August 17, 1951. She was apparently searching for a suitable *Formica* nest in which to start her colony. *Breviceps* has been collected at Devils Lake with *Formica montana* as the slave. (T. H. Hubbell, UMMZ).

A single worker of the form known as *P. rufescens bicolor* Wasmann was found at Station 9; the nest was not located. *Bicolor* is known from the Red River Valley (Wheeler and Wheeler, 1944) and from the Turtle Mountains (C. Thompson, UMMZ). Intergrades to "typical" *breviceps* occur in the western part of the Red River Valley. Because all other Ramsey County collections seem to be "typical" *breviceps*, and no intergrades to *bicolor* have been found there, this specimen of *bicolor* is a questionable record. It may have been the result of an accidental introduction.

In according *breviceps* specific status I have departed from current practice, as exemplified by Creighton (*op. cit.*). *Breviceps* and the European *P. rufescens* have much in common, and for this reason alone *breviceps* has been treated as a North American subspecies of *rufescens*. Until it can be shown that *breviceps* and *rufescens* are actually conspecific, I believe that it is better to consider the two as separate species.

REFERENCES

BAVENDICK, F. J. 1946—Climate and Weather in North Dakota. Bismarck, N. Dak.: State Water Conserv. Comm.

BRAUN, E. L. 1950—Deciduous forests of eastern North America. Philadelphia: Blakiston Company.

BROWN, W. L., JR. 1955—The ant *Leptothorax muscorum* (Nylander) in North America. Ent. News 64:43-50.

CARPENTER, J. R. 1940—The grassland biome. Ecol. Monogr. 10:617-684.

CLEMENTS, F. E. AND V. E. SHELFORD 1939—Bioecology. New York: John Wiley and Sons, Inc.

CREIGHTON, W. S. 1950—The ants of North America. Bull. Mus. Comp. Zool. 104: 1-585.

FENNEMAN, N. M. 1938—Physiography of the eastern United States. New York: McGraw-Hill Book Company, Inc.

SIMPSON, H. E. 1912.—Physiography of the Devils-Stump Lake Region, North Dakota. N. Dak. Geol. Survey, 6th Bienn. Rept.: 101-157.

WALSTER, H. L. 1924—The soils of North Dakota. Quart. J. Univ. N. Dak. 14:165-176.

WEBER, N. A. 1939—Descriptions of new North American species and subspecies of *Myrmica* Latreille (Hym.: Formicidae). Lloydia 2:144-152.

——— 1948—A revision of the North American ants of the genus *Myrmica* Latreille with a synopsis of the Palearctic species. Part II. Ann. Ent. Soc. Amer. 41:267-308.

——— 1950—A revision of the North American ants of the genus *Myrmica* Latreille with a synopsis of the Palearctic species. Part III. Ibid. 43:189-226.

WHEELER, G. C. AND E. W. WHEELER 1944—The ants of North Dakota. N. Dak. Hist. Quart. 11:231-271.

——— AND J. WHEELER 1955—The ant larvae of the Myrmicine tribe Leptothoracini. Ann. Ent. Soc. Amer. 48:17-29.

WILSON, E .O. 1955—A monographic revision of the ant genus Lasius. Bull. Mus. Comp. Zool. 113(1):1-199.

Parasitic and Some Nonparasitic Arthropods From Bat Caves in Texas and Mexico[1]

Raymond E. Ryckman

School of Tropical and Preventive Medicine, Loma Linda, California

During July and August, 1954, six species of bats were collected at five sites in the states of Texas, Veracruz, Sinaloa, and Tabasco. Specimens herein reported were collected by Dean Spencer, C. P. Christianson, and the author; at Teapa, Tabasco, Mexico, Karl Fischer and David Zinke assisted with the collecting. Parasitic and nonparasitic arthropods and bat species presented are listed in the following five sections by collection sites.

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Junction, Kimble County, Texas. July 11-12, 1954.

This cave, located fourteen miles southwest of Junction, Texas, was inhabited by the Mexican Free-tailed bat, *Tadarida mexicana* (Saussure, 1860) and *Myotis velifer incautis* (Allen, 1896). Arthropods associated with these bats were:

Diptera

Streblidae

Trichobius major Coq., 1899.—These parasites were collected on the walls of the cave about the bat roosts. They have previously been reported from Arizona, Florida, Kansas, and Texas (Stiles and Nolan, 1931).

Milichiidae

Leptometopa latipes (Mg.).—These flies were attracted to our lights in the interior of the cave in such large numbers that they were a nuisance to our collecting efforts; it is believed that the flies were breeding in bat guano on the floor of the cave.

Siphonaptera

Ischnopsyllidae

Myodopsylla sp.

Orthoptera

Tettigoniidae

Ceuthophilus cunicularis Hubbell

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ACARINA

Spinturnicidae
Spinturnix carloshoffmanni Hoffman, 1944.

Aragasidae
Ornithodoros yumatensis Cooley and Kohls, 1941.—This tick has previously been reported from *Myotis velifer* in Imperial County, California; Pinal County, Arizona; and Comal County, Texas (Cooley and Kohls, 1944).

ARANEIDA

Theridiidae
Theridion porteri Banks

Nesticidae
Gaucelmus augustinus Keyserling

BANDERA, MEDINA COUNTY, TEXAS. July 13, 1954.

The Ney Cave is located ten miles southwest of Bandera and contains a very high population of the Mexican Free-tailed bat, *Tadarida mexicana*. Unlike the other caves in this report the temperature was relatively high in this cave, that is, 86° F inside the entrance and 91° F in the central portion of the cave. An active dermestid cycle was established in the accumulation of guano. A bat was killed and placed on the floor of the cave and six hours later when it was examined, all of the skin and internal tissues had been stripped from the skeleton. Adult dermestids and streblids were constantly flying about the cave and alighting on members of the collecting party; irritating bites were received from the dermestids when they were in contact with exposed skin surfaces on arms, face, and neck.

Primicimex, the largest known bedbug, was readily collected on the floor and walls of the cave; eggs and immature instars were usually found in small crevices in the rock walls and ceiling of the cave. After considerable effort the author was rewarded by observing the feeding pattern of *Primicimex* on bats clinging to the cave ceiling and later by bats anesthetized with sodium nembutal and exposed to a colony of recently collected bedbugs. This giant bedbug repeatedly strikes the prospective host with its front legs and proboscis until no twitching or response is registered by the bat; at this point the bedbug lunges forward and firmly clamps its forelegs in a vise-like grip on a relatively small prominence of the bat's anatomy, that is, a section of the folded wing or leg. At the same time as the forelegs are brought into action the proboscis is also brought down on the host with considerable force at which time feeding takes place. The behavior pattern of this bug immediately prior to and during feeding is most unusual and interesting to observe.

The following arthropods were collected in this cave:

DIPTERA

Streblidae
Trichobius major Coq., 1899.
Trichobius sphaeronotus Jobl.—Previously reported from Nuevo Leon, Mexico (Stone, *in litt.*)

SIPHONAPTERA
Ischnopsyllidae
Sternopsylla distincta texana (Fox, 1914)

HEMIPTERA
Cimicidae
Primicimex cavernis Barber, 1941.—*P. cavernis* has been reported from only the Ney Cave in North America and one cave in Central America, that is, in Guatemala (Sailer, 1950).

COLEOPTERA
Dermestidae
Dermestes carnivorus F.

ACARINA
Aragasidae
Ornithodoros stageri Cooley and Kohls, 1941.—Previously reported from California, Arizona, Oklahoma, and the Ney Cave in Texas (Cooley and Kohls, 1944).

ARANEIDA
Theridiidae
Theridion porteri Banks
Latrodectus mactans Fabricius

PSEUDOSCORPIONIDA
Pseudoscorpions were collected but at this date have not been identified.

BOCA DEL RIO, VERACRUZ, MEXICO. July 22, 1954.

This collection point was not a cave, but rather an old, abandoned sugar mill that had been constructed of timber and stone and overgrown with vegetation. This structure is located approximately three kilometers west of Boca del Rio, on the south bank of the Rio Jamapa.

Two species of bats were collected at this site, namely, *Glossophaga soricina leachii* (Gray, 1843) and *Leptonycteris nivalis nivalis* (Saussure, 1860). Thick, viscous, semi-liquid feces accumulated under the bat roosts, perhaps because the diet of these bats consists of nectar. Many large dipterous larvae were breeding in the feces, these larvae were similar to Stratiomyidae. An attempt was made to rear the larvae to adults but they all died in the larval stage.

The following dipterous parasites were collected from the bat roosts:

DIPTERA
Streblidae
Trichobius sphaeronotus Jobl.—Previously reported from Nuevo Leon, Mexico (Stone, *in litt.*)

Euctenodes mirabilis Waterhouse, 1879.—Previously reported from Colombia, Brazil, Peru, Venezuela, Bolivia, Panama, Yucatan, British Guiana, and Trinidad (Stone, *in litt.*).

Nycterophila coxata Ferris, 1916.—Previously reported from California, British West Indies, Bahamas, Panama, and Brazil (Stone, *in litt.*).

TEAPA, TABASCO, MEXICO. July 27, 1954.

This vampire bat cave is located a few kilometers east of Teapa in the state of Tabasco, Mexico. The interior of the cave was quite damp—water dripped from the ceiling in many places; the floor of the cave was covered with a layer of wet slippery clay. A large pool, said to contain fish, was located in a branch of this rather large, extensive cave.

Two species of bats were present, the sac-winged bat, *Balantiopteryx plicata plicata* Peter, 1867, and the vampire bat, *Desmodus rotundus murinus* Wagner, 1840.

Arthropods from this cave are as follows:

DIPTERA

Streblidae

Trichobius parasiticus Gervais.—Previously reported from Brazil, Peru, French Guiana, Panama, Yucatan, and Cuba.

Psychodidae

Telmatoscopus albipunctatus (Will.).—Fifty-eight larvae of this species were collected from the accumulated liquid feces under a colony of vampire bats. Feces from the vampire bats and moisture in the cave formed small pools on the floor of the cave; in these small pools psychodids were breeding. Adult psychodids of this species were collected on the surface of the semi-liquid vampire bat feces which had collected on stalagmites under the bat roosts and at the edge of the pools mentioned above.

ACARINA

Spinturnicidae

Periglischrus vargasi Hoffmann, 1944.

PEDIPALPIDA

Tarantulidae

Tarantula fuscimana Koch.—It is unfortunate that the scientific and generic name for the whip-scorpion is *Tarantula* and that the common or popular name "tarantula" in this country refers to an entirely different group, that is, the large four-lunged spiders of the south and southwestern United States (Comstock, 1948).

MAZATLAN, SINALOA, MEXICO. August 15, 1954.

A number of specimens of the sac-winged bat, *Balantiopteryx plicata pallida* Burt, 1948, were collected in an unused silo three kilometers east of Mazatlan. The type locality for this bat is San Bernardo, Rio Mayo, Sonora, Mexico; the southern limit of the range of this bat is not known. No ectoparasites were found on these bats.

SUMMARY

Six genera of bats were collected at five sites—Texas, and the Mexican states of Veracruz, Tabasco, and Sinaloa. Ectoparasites associated with the bats were found to be: Streblidae—*Trichobius major, T. sphaeronotus, T. parasiticus, Euctenodes mirabilis,* and *Nycterophila coxata;* Ischnopsyllidae—*Myodopsylla* sp. and *Sternopsylla distincta texana;* Cimicidae—*Primicimex cavernis;* Spinturnicidae—*Spinturnix carloshoffmanni* and *Periglischrus vargasi;* Aragasidae—*Ornithodoros yumatensis* and *O. stageri.* Nonparasitic groups

collected in the caves were: Milichiidae and Psychodidae (Diptera), Dermestidae (Coleoptera), Tettigoniidae (Orthoptera), Theridiidae and Nesticidae (Araneida), Tarantulidae (Pedipalpida), and Pseudoscorpionida.

REFERENCES

COMSTOCK, J. H. 1948—The Spider Book. Revised by W. J. Gertsch, 1948. 729 pp. Comstock Publishing Co., Inc., New York.

COOLEY, R. A. AND G. M. KOHLS 1944—The Aragasidae of North America, Central America and Cuba. American Midland Naturalist Monogr. Ser. (1) 74-94.

SAILER, R. I. 1950—The second record for *Primicimex cavernis* Barber. Proc. Ent. Soc. Wash. 52(6):308.

STILES, C. W., AND M. O. NOLAN 1931—Key catalogue of parasites reported for Chiroptera (bats) with their possible public health importance. Natl. Inst. Health Bull. No. 155, U. S. Publ. Health Serv.

Redescriptions of Four Water-Mites of the Genus Aturus

Rodger Mitchell

University of Vermont, Burlington

Preliminary descriptions of four species of *Aturus* were published by Habeeb (1953a, 1953b) to obtain priority and that author has since lent me his full type series (two mounted specimens in each case) in order that these species could be redescribed. These more detailed descriptions are necessary if the species are to be recognized and entered into the taxonomic system as meaningful units rather than mere names validated by legal ritual.

In a previous paper (Mitchell, 1954) the biology of the genus *Aturus* was discussed together with the terminology commonly used in the description of aturid mites and at that time the unique terminology employed by Habeeb was considered. Also the nearctic *Aturus* were tentatively separated into three species groups. A complete listing of species with their assignments is given at the end of this paper.

Aturus droueti Habeeb

Aturus droueti Habeeb, 1953, Leafl. Acad. Biol., no. 1, p. 15.

Diagnosis.—Dorsum without internal ridges or pinnate setae, genital field with fine setae and four paddle-shaped setae on each side of the genital cleft, Leg IV without any flattened or serrate setae, and segment 4, leg IV with four elongate, mesally-directed simple setae.

This species is clearly a member of the acadiensis group. It lacks the abundance of setae on the posterior that is common in the group and the chaetotaxy approaches that of the desquamatus group.

DESCRIPTION OF MALE

Appendages (fig. 7).—Legs I-III unmodified. Segment 4, leg IV with two very broad setae on the disto-lateral tip; inner setae broad, blunt, and over half the length of the following segment, the outer a simple, fine seta half as long as the inner: two other groups of setae present. a group of four elongate mesally-directed setae, and three other large setae placed distally and extending parallel to the segment. Segment 5, leg IV with three proximally-placed setae on the ventral surface.

Dorsum (fig. 1).—Lateroglandularia I-IV observed, I with a short fine setae; II with a heavy bifid seta and placed just lateral to a marginal fold in the dorsal shield; setae of III and IV not seen. Seta of dorsoglandularia I large, bifid; II-IV small, bearing fine simple setae; IV located just anterior to the anal pore; V near the posterior margin, the pore and simple seta separated. A distinctive dorsal depression located just anterior to a line drawn through dorsoglandularia II and III. Posterior margin weakly fused, if at all, with the venter. Integumentary markings reticulate and finely punctate. Muscle scars granular.

Venter (fig. 4).—Integument finely punctate; muscle scars obscure fine lines. Two prominent ventroglandularia; one by the second genital acetabulum from the genital cleft, the other by the fourth or fifth acetabulum from the genital cleft.

Genital field (fig. 4).—With 11 to 12 irregular acetabula along the posterior margin. Around 20 fine, simple, very short setae project posteriorly from the genital field. Four simple setae on the ventral surface lateral to the genital cleft.

SPECIMENS: *Cotypes.*—Male, tributary of the Salmon River, Victoria County, New Brunswick, June 30, 1953; male, Rapide de Femme Brook, Grand Falls, New Brunswick, June 25, 1953.

MEASUREMENTS: Dorsal shield 0.32 mm long, 0.275 mm wide; venter 0.380-0.425 mm long; length of leg segments III-5, 0.129-0.140 mm; III-6, 0.125-0.140 mm; IV-4, 0.095-0.105 mm; IV-5 0.160-0.180 mm; IV-6, 0.140-0.145 mm.

ATURUS CANADENSIS Habeeb

Aturus canadensis Habeeb, 1953, Natural. Canad. 80:274-275.

Diagnosis.—Segment 4, leg III with a row of setae on the posterior surface, no paddle-shaped setae on the posterior, dorsum without pinnate setae or ridges, seta and pore of dorsoglandularia I separated, leg IV without flattened setae, and the two large sword-shaped setae of segment 4, leg IV subequal.

Species of the acadiensis group show a combination of features found in the simpler desquamatus group and the more modified hoplomachus group. While *A. canadensis* fits within the defined limits of the acadiensis group (Mitchell, 1954) the species resembles certain of the hoplomachus group. In view of this fact, it must be reemphasized that the classification proposed on the basis of our limited knowledge of the genus must be flexible and subject to change as more species become known.

DESCRIPTION OF MALE

Appendages (fig. 10).—Legs I-II unmodified; segment 4, leg III with 15 to 20 long, simple setae; nine setae in a row on the ventro-posterior surface, six irregularly-placed setae dorsal to this row, and four setae on the dorsal part of the distal margin of segment 4. Segment 4, leg IV with two broad subequal setae nearly as long as the succeeding segment that originate on the disto-lateral angle, the inner member bent and twisted; a group of three longer setae originate proximal from these; and four short setae originate on the meso-distal surface of the segment. Segment 5, leg IV with two groups of setae on the ventral surface of the segment; a closely-set median row of five short simple setae and mesal to these a row of four heavier, longer setae.

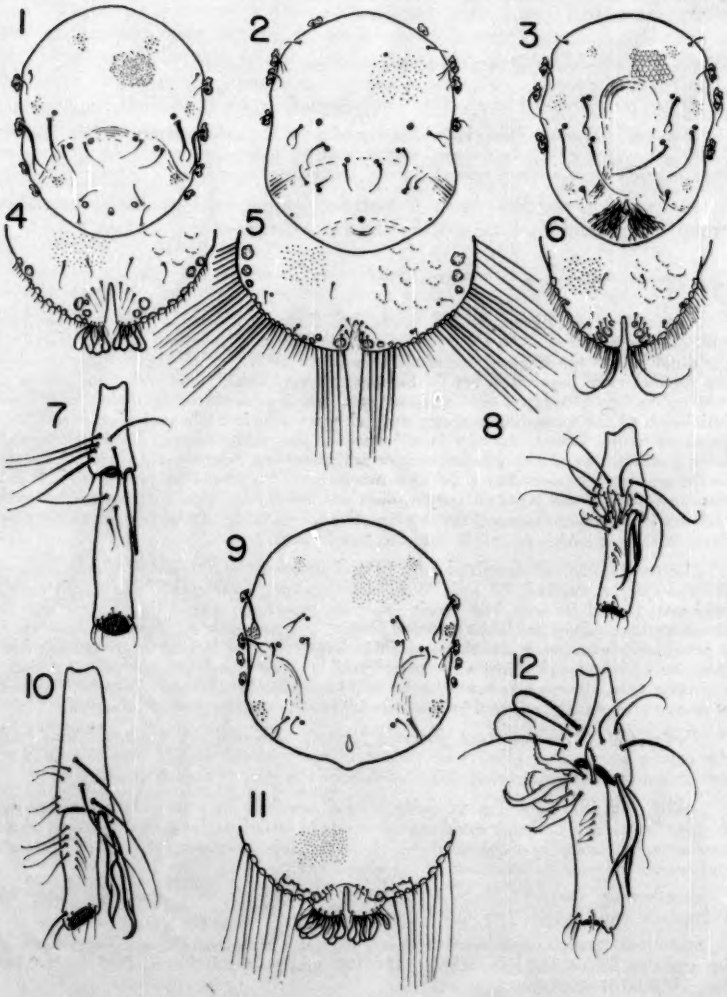
Dorsum (fig. 2).—Lateroglandularia I-IV observed; I, III, and IV with a fine simple seta, II with a bifid seta. Dorsoglandularia I with seta lateral to the pore, a bifid seta lateral to the pore; dorsoglandularia II-III mesal of I and bearing a simple seta; dorsoglandularia IV with a simple seta; V separated, pore at the posterior margin and the seta lateral to IV. Dorsum very weakly fused with the venter posteriorly. Integumentary markings fine, prominent anteriorly but nearly absent in the posterior quarter of the dorsum. Muscle scars fine, weakly granulate.

Venter (fig. 5).—Integument marked by fine coarse punctations. Muscle scars obscure, made up of small linear marks. Two pairs of glandularia near the posterior margin; one by the sixth or seventh acetabulum lateral to the genital cleft, the other by the twelfth acetabulum.

Genital field (fig. 5).—Fourteen to seventeen rather large circular acetabula irregularly-placed along the ventral margin. Anterior and posterior areas of the genital field with very elongate simple setae and the setae between these groups half the length of the other setae. Three or four very fine setae on the venter just lateral to the margins of the genital cleft.

SPECIMENS: *Cotypes.*—Male, Rapide de Femme Brook, Grand Falls, New Brunswick, June 25, 1953; male, Coldbrook, Grand Falls, New Brunswick, September 2, 1953.

MEASUREMENTS: Dorsal shield 0.355 mm long, 0.275 mm wide; venter 0.435 mm



Figs. 1-12.—1. *Aturus.* 1. *A. droueti,* dorsum; 2. *A. canadensis,* dorsum; 3. *A. ennishonensis,* dorsum; 4. *A. droueti,* venter; 5. *A. canadensis,* venter; 6. *A. ennishonensis,* venter; 7. *A. droueti,* leg IV; 8. *A. ennishonensis,* leg IV; 9. *A. mirabilis,* dorsum; 10. *A. canadensis,* leg IV; 11. *A. mirabilis,* venter; 12. *A. mirabilis,* leg IV.

All leg drawings are of the right hand leg IV, ventral aspect of segments 4 and 5. The drawings of the venter show the posterior region and the genital field; muscle insertions are indicated on the right side, integumentary markings on the left. The dorsal shield and lateroglandularia are shown in drawings of the dorsum with the integumentary pattern indicated for a small area.

long; length of leg segments III-5 0.150-0.165 mm, III-6 0.135-0.140 mm, IV-4 0.160-0.165, IV-5 0.180-0.145 mm, IV-6 0.135 mm.

ATURUS ENNISHONENSIS Habeeb

Aturus ennishonensis Habeeb, 1953 Leafl. Acad. Biol., no. 1, pp. 15-16.

Diagnosis.—Segment 5, leg III with a row of setae along the posterior surface, segment 5, leg IV with five broadly flattened serrate setae at its base, no paddle-shaped setae on the posterior margin, dorsum without internal ridges or pinnate setae.

A. ennishonensis has the least modified genital field in the hoplomachus group and is similarly little modified in the structure of the dorsum.

DESCRIPTION OF MALE

Appendages (fig. 8).—Legs I-II unmodified. Segment 5, leg III with two ill-defined rows of long simple setae on the posterior surface; nine to eleven setae ventrally-placed on the distal half of the segment, five or six setae in the middle of the segment just dorsal to the previous row. Segment 4, leg IV broadly expanded distally and with three groups of setae on the ventral surface; two subequal sword-shaped setae extending distally nearly the full length of the succeeding segment; three elongate disto-laterally projecting setae placed proximal to the former, the two lateral setae of the group simple, the mesal member bifid; a curved row of four anterio-ventrally projecting setae near the disto-posterior margin of the segment. Segment 5, leg IV with two groups of setae on the ventral surface: five closely-set setae at the proximal margin, the three mesal setae with a deep terminal notch and the lateral margin serrate, the two lateral setae with the lateral margin serrate; just distal to these, a closely-set row of five erect simple setae.

Dorsum (fig. 3).—Lateroglandularia I-IV observed; setae of I and II simple, setae of III and IV not observed, III and IV set close together. Dorsoglandularia I with a long bifid seta; II and III with long simple setae; IV prominent, with a short simple seta; V obscure, placed along the latero-posterior margin, the pore may be absent. Dorsum with a prominent depression in the shape of an inverted "T" but lacking any internal ridges. Posterior of the dorsal shield with a group of over 40 closely-set, elongate, anteriorly-projecting setae. Integument marked by a very strong areolate pattern. Posterior two pairs of muscle scars weakly indicated by fine punctations, the anterior pair not observed.

Venter (fig. 6).—Integument distinctly punctate. An oval row of granulations mark the muscle scars. Two glandularia present at the posterior margin; one by the third acetabulum lateral to the genital cleft, the other by the sixth or seventh acetabulum.

Genital field (fig. 6).—Ten to twelve gentital acetabula in a row along the posterior margin. Three or four larger ovoid genital acetabula lateral to the genital cleft and about four setae just lateral to these acetabula. A row of fine setae along the posterior margin and two curved setae on either side of the genital cleft.

SPECIMENS: *Cotypes.*—Male, Little River, Grand Falls, New Brunswick, June 16, 1953; male, same locality, July 1, 1953.

MEASUREMENTS: Dorsal shield .265 mm wide; venter 0.360-0.370 mm long; length of leg segments III-5 0.150 mm, III-6 0.145-0.150 mm, IV-4 0.100 mm, IV-5 0.140-0.145 mm, IV-6 0.160-0.165 mm.

ATURUS MIRABILIS Piersig

Aturus scaber Koenike, 1895. Abh. naturw. Ver. Bremen. 13:186-191.

Aturus mirabilis Piersig, 1897. Sitzungs. naturf. ges. Leipzig. 22-23:157.

Aturus projector Habeeb, 1953, Natural. Canad., 80:275.

Diagnosis.—A swollen genital region bearing seven paddle-shaped setae, dorsum without internal ridges or groups of setae on the posterior margin, and the proximal setae of segment 5, leg IV broad and serrate on both sides.

This species is known from only two small collections. Types referable to the name *mirabilis* do not appear to be available except for a female palp in the Marshall Collection and a female deposited in the Canadian National Museum. Neither specimen is useful for comparison. Koenike's description, which was designated the type description, is lacking in the details necessary to distinguish species of *Aturus* at present. A rather diagrammatic drawing of the venter and the legs show a number of distinctive characteristics that are identical to those of *A. projector*. There are no described characters that will separate the two species and the synonymy is unavoidable on this basis.

DESCRIPTION OF MALE

Appendages (fig. 12).—Legs I-II unmodified. Segment 5, leg III bearing about 30 elongate setae irregularly-placed over the posterior surface; five somewhat longer setae dorsal to this group and located more in the center of the segment. Segment 4, leg IV distally expanded and bearing simple setae; two sword-shaped setae originate on the disto-lateral tip; three long simple setae proximal to these; four other long simple setae placed ventro-laterally on the segment. Segment 5, leg IV with a proximal group of five elongate broad setae with lateral serrations and a row of five closely-set simple setae on the ventral surface.

Dorsum (fig. 9).—Lateroglandularia I-IV set close together lateral to the dorsal shield; setae of I-II heavy and bifid; setae of III and IV small and simple. Dorsal shield without groups of setae on the posterior region. Integument marked by extremely fine punctures. Muscle scars marked by coarse granulations. Dorsal shield with the latero-posterior margins depressed, and a fold along the lateral margin by lateroglandularia IV.

Venter (fig. 11).—Integument coarsely punctate, muscle scars irregular lines. Two prominent projecting glandularia, one by the second, the other by the third or fourth genital acetabulum from the genital cleft.

Genital field (fig. 11).—The region around the genital cleft expanded and prominent. A large circular genital acetabulum just lateral to this enlarged area and seven to nine irregularly-shaped terminal acetabula. Three fine simple setae lateral to the genital cleft; six or seven pairs of paddle-shaped setae clustered about the genital cleft; and about nine very elongate simple setae on each side of the posterior margin.

SPECIMENS: 2 males (cotypes of *A. projector*). Tributary of the Salmon River, Victoria County, New Brunswick, September 6, 1953.

MEASUREMENTS: Dorsal shield 0.285-0.295 mm wide; venter 0.405-0.430 mm long; length of leg segments III-5 0.160-0.165 mm, III-6 0.150 mm, IV-4 0.130 mm, IV-5 0.135, IV-6 0.127.

NEARCTIC SPECIES OF THE GENUS ATURUS

DESQUAMATUS group
- *desquamatus* Mitchell, 1954.
- *estellae* Habeeb 1953a.
- *formosus* Habeeb, 1953a.
  - syn. *pallidus* Habeeb, 1953a.
- *nelsoni* Mitchell, 1954.
- *pellucidus* Habeeb, 1954.
- *semilineatus* Habeeb, 1953a.

ACADIENSIS group
- *acadiensis* Habeeb, 1953a.
- *canadensis* Habeeb, 1953b.
- *droueti* Habeeb, 1953a.

HOPLOMACHUS group
- *amnigenus* Mitchell, 1954.
- *aulix* Mitchell, 1954.
- *deceptor* Habeeb, 1953b.
- *ennishonensis* Habeeb, 1953a.
- *hoplomachus* Mitchell, 1954.
- **imitator* Habeeb, 1954.
- *interceptor* Habeeb, 1954.
- *mirabilis* Piersig, 1897.
  - syn. *scaber* Koenike, 1895.
  - *projector* Habeeb, 1953b.
- *ortivus* Habeeb, 1954.
- **receptor* Habeeb, 1954.
- *subtusus* Mitchell, 1954.
- *varus* Habeeb, 1954.

* Tentative assignments based on incomplete descriptions.

REFERENCES

HABEEB, H. 1953a—North American Hydrachnellae, Acari. I-V. Leafl. Acad. Biol. (1):1-16.

———1953b—North American Hydrachnellae, Acari. VI. Natural. Canad. 80:274-277.

———1954—North American Hydrachnellae, Acari. IX-XVI. Leafl. Acad. Biol. (2):1-14.

KOENIKE, F. 1895—Nordamericanische Hydrachniden. Abh. naturw. Ver. Bremen 13:167-226.

MITCHELL, R. D. 1954—Water-mites of the Genus *Aturus* (Family Axonopsidae). Trans. Amer. Micros. Soc. 73:350-367.

PIERSIG, R. 1897—Eine neue Hydrachniden-Gattung. Sitzungs. naturf. Ges. Leipzig 22-23:155-157.

The Mussel Population of an Area of Loamy-Sand Bottom of Lake Texoma[1]

Carl D. Riggs and Glenn R. Webb
University of Oklahoma, Norman

Published accounts of studies of fresh-water mussel populations in the United States are few. During the period when the pearl button industry was at its height, mussel "fishing" was extensively practiced, and the mussel fishery intensively studied by the U. S. Bureau of Fisheries, many faunal papers were published which listed the mussels of various lakes, rivers, and drainage basins. These papers included general statements on the habitat preferences and the abundance of mussels, but little exact and specific data on the number of mussels per unit of area of stream or lake bottom.

Information on mussel populations in impounded waters is even more scarce. Where impoundment occurs, undoubtedly it is responsible for the eradication of some species which lived in the stream before impoundment; it has little effect on other species, and even favors some species. Coker et al (1922), stated that wing dams in the upper Mississippi River often produced environments unfit for mussels that were formerly abundant in the same portion of the river. They also stated that lakes with a free circulation of water seem to be favorable to mussels, particularly those situated in the course of a river. This was not a reference to impoundments, however, but to lakes such as Lake Pepin in the Mississippi River. Similar conditions are present in certain impoundments, and in the absence of environmental factors decidedly detrimental to mussels (e.g., heavy siltation; extreme water level fluctuations; pollution) such impoundments should support large mussel populations, in many cases much larger than were supported by comparable areas of the river before impoundment.

Lake Texoma is formed by the Denison Dam which impounds the Red River just downstream from its confluence with the Washita River (Bryan County, Oklahoma; Grayson County, Texas). The United States Department of Interior (1943), the Oklahoma Planning and Resources Board (1946; 1953), and the U. S. Army Engineers (1948) give pertinent general data on this lake.

The Red River, because of its heavy silt load and constantly changing bed, is unsuited for mussels (Coker *et al.*, 1922; Isely, 1924). Isely (1924)[2] carefully examined its bed in three areas (all of which are now within Lake Texoma) and found very few mussels—52 living specimens and several shells, representing eight species in all. The shells included: *Quadrula pustulosa, Q. forsheyi* (= *Q. quadrula*, Neel, 1941), *Lampsilis ventricosa*, and *Anodonta*

[1] Contribution of the University of Oklahoma Biological Station, Lake Texoma.

[2] Coker *et al.* (1922) said that Isely (1914) examined the Red River and found few mussels. Our examination of Isley (1914) showed no such statement. They probably referred to Isely (1924) which was submitted to the U. S. Bureau of Fisheries about 1914, but was never published by that organization due to World War I. This same manuscript was later published in the *Proc. Okla. Acad. Sci.*, Vol. 4.

grandis. The living species were: *Proptera* (=*Leptodea*) *laevissima* (40 specimens), *Leptodea fragilis* (8 specimens), *Truncilla donaciformis* (2 specimens), and *Lampsilis fallaciosa* (2 specimens).

The Washita River also has been classed as a poor mussel stream by Isely (1924). His intense collecting (one of his collecting sites is now included in Lake Texoma) revealed 12 species, including seven of the eight mentioned above (*Anodonta grandis* excluded), plus *Lasmigonia complanata*, *Obliquaria reflexa*, *Tritogonia verrucosa* (= *T. tuberculata*), *Proptera purpurata*, and *Carunculina parva*. *Leptodea laevissima* was the only abundant species. During extensive seining in the Washita River during the past five years, Riggs has found mussels only in the upper portions of the river.

Conditions in many of the tributaries of both the Red and Washita rivers are undoubtedly suitable to support sizeable mussel populations of many species. This is substantiated by Isely (1924), who found a total of 42 species in the Red River tributaries.

No thorough study of the mollusks of Lake Texoma has been made. Mollusk collections made by classes in invertebrate zoology at the University of Oklahoma Biological Station, and those which Riggs has made incidentally while seining fishes, do not indicate the presence of a large mussel population, either of species or of individuals. Sublette (1956) reported five species of mussels in Texoma: *Quadrula q. apiculata*, *Truncilla donaciformis*, *Leptodea laevissima*, *Anodonta corpulenta*, and *A. imbecillis*. We have taken four of these five species in Lake Texoma (*A. corpulenta* excluded); also *A. grandis Carunculina parva*, and *Leptodea fragilis* (table 1). Of the seven species which we took, *Leptodea laevissima*, *L. fragilis*, *Andonta grandis*, *Q. quadrula*, and *Carunculina parva* were taken as both living specimens and shells. The remaining species are represented only by shells found on the lake bottom exposed by low water. Only one of the seven species which we took, *Andonta imbecillis*, was not listed by Isely (1924)[3] from the Red or Washita rivers, although it was listed as taken from several tributaries. Some of Isely's specimens are in the University of Oklahoma Museum of Zoology.

On July 14, 1953, Riggs visited a large flat peninsula (approximately 60 acres) immediately downstream from the mouth of Big Mineral Creek in Grayson County, Texas. This area was normally lake bottom, but due to low water it was exposed at the time of Riggs' visit. Several thousand mussel shells were scattered over this area. It had been a peanut field before it was inundated. Some of the plow furrows faintly showed and parts of many dead peanut plants remained, still partly rooted. About one-third of this area was a very shallow basin with gently sloping sides about 8 to 12 inches higher than the floor. Most of the shells in this shallow basin were still imbedded in the earth in the position of living mussels. Because of the size and shape of the basin, its near-center location in the large flat area, and the rapid rate at which the lake falls during the times of year when this

[3] Isely's table of mussels from the Red River drainage lists *Anondonta corpulenta* from the Red River. From reading his text (p. 51) it is obvious that this is a transposition and the species should be *A. grandis* (listed immediately below *A. corpulenta* in the table).

area has been exposed (April 1 to 8; October 1 to 9, 1952), it seems almost certain that all living mussels literally "died in their tracks." It is improbable that any within the basin escaped. Those that retreated with the lowering water moved toward the center of the basin where they were trapped when the water level fell below the rim of the basin. Most of them were probably killed by high water temperature[4] during September and October, 1952, before the entire area was exposed, since surface temperatures of water less than two feet deep are often above 80° F through mid-October. There was no indication that the shells had been disturbed; no human or livestock tracks were evident.

The situation seemed to offer an excellent opportunity for a population study. Examination of recorded lake levels since impoundment first began (January 6, 1944), and Riggs' field notes for 1949, furnished data which indicated that it was an extraordinary opportunity. The area was first inundated in February, 1945. It remained covered until January, 1949. During this time the depth of the water over the area varied from 0 to 19 feet, and was more than 3.5 feet deep until November, 1948. The area was exposed for at least 20 days during January and February of 1949 which should have killed any mussels present.

On February 5, 1949, Riggs made a careful examination of the ground in the area and noted that "mollusks were practically nonexistent and were probably quite scarce in the entire lake." Although we have no data which verify this, it is logical that such scarcity did exist when the following facts and possibilities are considered: (1) The lake was only four years old. (2) Both the Red and Washita rivers are poor mussel streams. (3) The lake environment might not be suitable for some of the few stream-dwelling species that were present at impoundment, as well as for some of the host fishes. (4) The sudden great increase in water volume would dilute, at least temporarily, some of the important host fishes. (5) Much of the bottom would at first be unsatisfactory to support mussels.

The area was again inundated by late February, 1949, and remained covered (minimum depth—2.0 feet; maximum—18.5 feet) until early April, 1952. It was exposed for 14 days, re-inundated by the end of April, and re-exposed by October 8, 1952. It remained exposed until after the time of this study, July, 1953.

The above data indicated that most of the shells distributed over the shallow basin represented a mussel population established between February, 1949, and April, 1952. Although many young mussels might have been shed from host fishes over this area between April and October, 1952, none could have attained the size of most of the specimens which we collected. Except for the two small species, *Carunculina parva* and *Truncilla donaciformis*, very few shells under one inch in length were found and growth rings indicated that very few were less than one year old. It seems unlikely that

[4] No data indicating temperatures lethal to mussels can either be furnished or found in the literature. Without exception, however, it was noticed that in Lake Texoma mussels caught in shallow, warm water by a falling lake level either move into deeper water or die within two days.

many individuals could have migrated into the area during the seven-month period. This would have required straight-line movement of at least 100 yards. Remarks about mussel migration and movement by Coker, *et al.* (1922), and Isely (1914; 1924) indicate that in favorable environments, mussels, especially the heavy-shelled forms, rarely move far from the place where they were dropped. Furthermore, the fact that the water level was falling during half of the seven-month period should have caused movement away from the area and into deeper water. Such movement by *Leptodea laevissima* was described by Isely (1924) who found that this species also moved up the bank with rising water. Some of the larger shells of *L. laevissima* which we collected appeared to be four years old or older, and might have migrated into the area after it was re-inundated in 1949 or 1952. It is also possible that some of these old shells are the remains of mussels that died during the 1949 exposure, or that survived the 20-day period of exposure (as young mussels) and lived on until 1952 after the area was re-inundated. However, Riggs should have found any old shells during his examination of the area in 1949.

On July 17, 1953, we visited this area of exposed lake bottom and began a study of the clam population based on the number of shells collected. We had decided to establish a number of quadrats at random over the shallow basin. All quadrats were 50-foot squares, and were laid out with four sticks connected by heavy string. A 100-foot steel tape was used to measure the sides and construct the 90° angles. We were careful not to walk through a quadrat and step on shells.

When a quadrat was established one of us walked to its center, picking up any shells that were in our path, and set down a box. We then worked away from the box in a tight spiral pattern, returning periodically to the box to deposit shells. After this had been done several times, we traversed the quadrat in a boustrophedonic pattern, both parallel with its sides and at 45° to them. This was continued until no additional shells were found. All fragments were picked up. Each box was dated, and its contents later analyzed

TABLE 1.—Kind, number, and size of mussels (shells) found on an area of exposed bottom of Lake Texoma, 1953.

Species	Total number of shells	Number of fragments (umbos)	Number of entire individuals	Average number per quadrat	Range in numbers per quadrat	Average length of shell (mm)	Range in length of shell (mm)
Anodonta grandis	17	3	14	1.7	1-6	131.8	100-156
A. imbecillis	2	0	2	0.2	0-1	35.5	31-40
Carunculina parva	31	15	16	3.1	0-7	23.6	17-32
Leptodea fragilis	2	0	2	0.2	0-1	113.5	98-129
L. laevissima	536	62	474	53.6	27-95	123.6	42-161
Quadrula quadrula	220	60	160	22.0	12-33	43.7	11-101
Truncilla donaciformis	90	11	79	9.0	5-21	72.4	10-50
Total and grand average	898	151	747	89.8			

in the laboratory. Only those shell fragments including umbos were counted as shells, and opposite umbos were matched. The type and condition of the soil was noted. Altogether ten quadrats were examined.

The data in table 1 show *Leptodea laevissima* (536 specimens) to have been far more abundant than all of the other six species combined (a total of 362 specimens). It is the dominant mussel in the lake. *Q. quadrula* (220 specimens) was more abundant than all of the remaining species (142 specimens). These two species were also the most abundant in the incidental and general mollusk collections mentioned earlier from the lake. Some of the factors that have probably contributed to their success follow: (1) The chief host reported for *L. laevissima* (Baker, 1928), the freshwater drum (*Aplodinotus grunniens*), is abundant in Lake Texoma. (2) The unusual migratory ability of *L. laevissima* (Coker, *et al.*, 1922; Isely, 1924). (3) The rapid growth-rate of *L. laevissima* (Coker, *et al.*, 1922) and the thick, heavy shell of *Q. quadrula*, two factors making these species unavailable or generally unsuitable for fish food. (4) The quadrulas tend to remain in deep water (Coker, *et al.*, 1922; Isley, 1914) and thus avoid exposure and stranding by receding water. (5) The quadrulas are also able to endure unfavorable conditions (Isely, 1914). (6) *L. laevissima* appears to have been the dominant mussel in the Red and Washita rivers before impoundment (Isely, 1924).

From our data it was impossible to draw sound conclusions about the relative abundance of the remaining species throughout the lake. There was little variation in the soil of the ten quadrats. Two of them contained fine gravel (these were two of the three quadrats with over 100 shells), and two of them contained little sand (these contained the fewest shells). It seems probable that there was too much sand for an ideal environment for those species preferring a mud bottom. We have collected *Anodonta grandis* and *Leptodea fragilis* in far greater relative abundance in other parts of the lake with a mud bottom. Another area of the peninsula where the bottom was soft mud was much more densely populated with *A. grandis*. These soft-bottom-frequenting forms are, therefore, probably more abundant in the entire lake than the quadrat data indicate.

From general but careful observations of the distribution and number of shells scattered over the basin area of the peninsula, we believe that the data from the ten quadrats give a good estimate of the entire population of

TABLE 2.—Numbers of each species of mussels (shells) found in each of ten quadrats.

	1	2	3	4	5	6	7	8	9	10	Total
Leptodea laevissima	49	49	54	36	47	34	95	27	86	59	536
Quadrula quadrula	20	20	14	21	32	12	33	20	27	21	220
Truncilla donaciformis	6	6	21	13	13	6	9	6	5	5	90
Carunculina parva	2	5	7	2	4	2	5	....	3	1	31
Anodonta grandis	....	2	6	2	3	1	....	....	2	1	17
A. imbecillis	....	....	1	....	....	1	....	....	....	....	2
Leptodea fragilis	....	....	1	1	....	....	....	....	....	....	2
Total	77	82	104	75	99	56	142	53	123	87	898

the area. Expanding the average quadrat population (table 1) over the whole area gives a density of 0.36 mussels per square foot; 15,647 per acre. This is low when it is compared with stream populations. Clark and Wilson (1912) reported a density of 7.5 mussels per square foot. According to Coker, *et al.* (1922), mussel densities of three per square foot were found in Grand River, Michigan, and 16.5 per square foot in the Clinch River, Tennessee. They also stated that it is fair to assume that a density of more than three or four mussels per square foot over any considerable area is unusual. After an analysis of the data it is impossible to say whether this population density, 0.36 mussels per square foot, compares favorably with other impoundments. We found no comparable data in the literature, and even had this been possible it would mean little since eclogical conditions in different impoundments are so variable. The specific effects of such conditions on the mussel population of Lake Texoma are unknown at the present.

Because of the homogeneity of the bottom of the area studied, and because of the lack of knowledge of other environmental factors (i.e., food, current, dissolved oxygen, etc.) which should have been equally homogeneous, little valuable information on interspecific associations can be gained from the data in table 2. That these species do occur together is obvious.

We are grateful to Dr. Henry van der Schalie of the University of Michigan Museum of Zoology for verifying our identifications of the mussels.

SUMMARY

Isely (1924) reported 13 species of mussels from the Red and Washita rivers in Oklahoma, and a total of 43 species from the tributaries of the Red River.

Eight species of mussels have been taken from Lake Texoma, all of which were included in Isely's list of 43 species from the Red River and its tributaries.

Two of the Texoma species, *Anodonta corpulenta* and *A. imbecillis*, were not taken by Isely from the Red or Washita rivers.

Ten quadrats were established on a large area of exposed, loamy-sand lake bottom and all mussel shells present were collected, identified, and counted.

The quadrat samples included 7 species of mussels: *Anodonta grandis, A. imbecillis, Carunculina parva, Leptodea fragilis, L. laevissima, Quadrula quadrula,* and *Truncilla donaciformis.*

All species were associated with one another in the area sampled.

According to the data, *Leptodea laevissima* is the dominant species of mussel in Lake Texoma, followed by *Quadrula quadrula.*

Analysis of the quadrats showed a density of 0.36 mussels per square foot, or 15,647 per acre.

REFERENCES

BAKER, F. C. 1928—The fresh water mollusca of Wisconsin. Part II. Pelecypoda. Wisc. Geol. and Nat. Hist. Surv. Bull. 70, Part 2.

COKER, R. E., A. F. SHIRA, H. W. CLARK, AND A. D. HOWARD 1922—Natural history and propagation of fresh-water mussels. Bull. U. S. Bur. Fish. 37(1919-1920):75-181.

CLARK, H. W., AND C. B. WILSON 1912—The mussel fauna of the Maumee River. U. S. Bur. Fish. Doc. 757:1-72.

ISELY, F. B. 1914—Experimental study of the growth and migration of fresh-water mussels. U. S. Bur. Fish. Doc. 792:1-24.

——— 1924—The fresh-water mussel fauna of eastern Oklahoma. Proc. Okla. Acad. Sci. 4:43-118.

NEEL, J. K. 1941—A taxonomic study of *Quadrula quadrula* (Rafinesque). Occas. Papers Mus. Zool., Univ. Mich., No. 448:1-8.

OKLAHOMA PLANNING AND RESOURCES BOARD 1946—Oklahoma lakes. Pp. 1-31.

——— 1953—Oklahoma's water resources. Pp. 1-34.

SUBLETTE, J. H. (In press)—The ecology of the macroscopic bottom fauna in Lake Texoma. Amer. Midl. Nat.

U. S. ARMY CORPS OF ENGINEERS 1948—Denison Dam and Lake Texoma information pamphlet Red River, Texas and Oklahoma. Tulsa District, Revision of March, 1948 (mimeo.):1-22.

U. S. DEPT. OF INTERIOR 1943—Recreational resources of the Denison Dam and Reservoir project Texas and Oklahoma. Nat. Park Serv. Oct., 1943:1-98.

A Comparative Study of the Cephalic Lateral-Line System of North American Cyprinidae[1]

Helen J. Illick[2]
Russell Sage College, Troy, New York

The present comparative study of the lateral-line canals on the head of some of the North American Cyprinidae was undertaken to make possible a better understanding of the relationship of these fishes. However, it was realized that phylogenetic relationship could not be demonstrated on the basis of this character alone. Progress toward a natural classification in a large family like the Cyprinidae depends upon the completion of studies of many morphological characters.

The lateral-line canals of the head of eighty-three forms including subspecies, representing thirty-eight genera, were studied to determine the generalized pattern for the family as well as the individual and group variations of this pattern. It is obvious that a full understanding of the lateral-line characters of a genus is not possible until every species of the genus is studied. Neither material nor time was available to complete such a study. However, species that seemed to characterize a genus best were chosen. Detailed descriptions of the cephalic lateral-line canals of each of the species studied are in the author's doctoral dissertation, which is available at the Cornell University library.

Review of Literature

According to Ewart (1891), Stenonis in 1664, Lorenzini in 1678, Monro secundus in 1785, and Leydig in 1850 were among the early scientists to observe and describe the lateral-line canals of the head in fishes. However, Allis (1889) using *Amia calva* made the first detailed and basic study of the anatomy and development of the cephalic lateral-line canals.

Theories as to the function of the lateral-line canals have been postulated by Schulze (1870), Garman (1888), Ewart (1891), Fuchs (1895), Lee (1898), Hofer (1908), Parker and Van Heusen (1918), Herrick (1927), Smith (1930, 1933), Daget (1950), and Kleerekoper and Chagnon (1954).

Several studies have been made from a comparative morphological or phylogenetic viewpoint by Allis (1934), Hubbs and Cannon (1935), Säve-Söderbergh (1941), Holmgren (1942), Hubbs, Walker and Johnson (1943), Tretiakov (1944), Tchernavin (1946), Stensiö (1947), Miller (1948), Gosline (1949), Holmgren and Pehrson (1949), and Pehrson (1949).

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Various works also treat the cephalic lateral-line canals in fishes; such as, chimaera (Solger, 1880; Collinge, 1895a) *Raia batis* (Ewart and Mitchill, 1891), siluroids (Pollard, 1892), *Lepisosteus osseus* (Landacre and Conger, 1912), selachians (Johnson, 1917), *Torpedo marmorata* (Norris, 1932), *Clupea harengus* (Bramford, 1941), Scombricidae (Tretiakov, 1941), *Esox lucius* (Pehrson, 1944), *Leuciscus rutilus* (Devillers, 1944), *Cyprinus carpio* and *Blicca bjornka* (Tretiakov, 1944), *T. tinca* (Tretiakov, 1948), and *Gymnarchus niloticus* (Pehrson, 1945).

Few investigations, however, have been made of the lateral-line canals of the head of the Cyprinidae except for *Abramis blicca* (Sagemehl, 1891), *Labeo dussumieri* (Collinge, 1895), *Tinca* (Andres, 1899), *Carassius auratus* (Allis, 1904), *Phoxinus laevis* (Manigk, 1933), *Leuciscus rutilus* (Devillers, 1944), *T. tinca* (Tretiakov, 1948), *Leuciscus rutilus, P. phoxinus, A. alburnus, Abramis blicca,* and *T. tinca* (Lekander, 1949), and *Notropis volucellus* and *N. buchanani* (Bailey, 1951).

METHOD AND MATERIALS

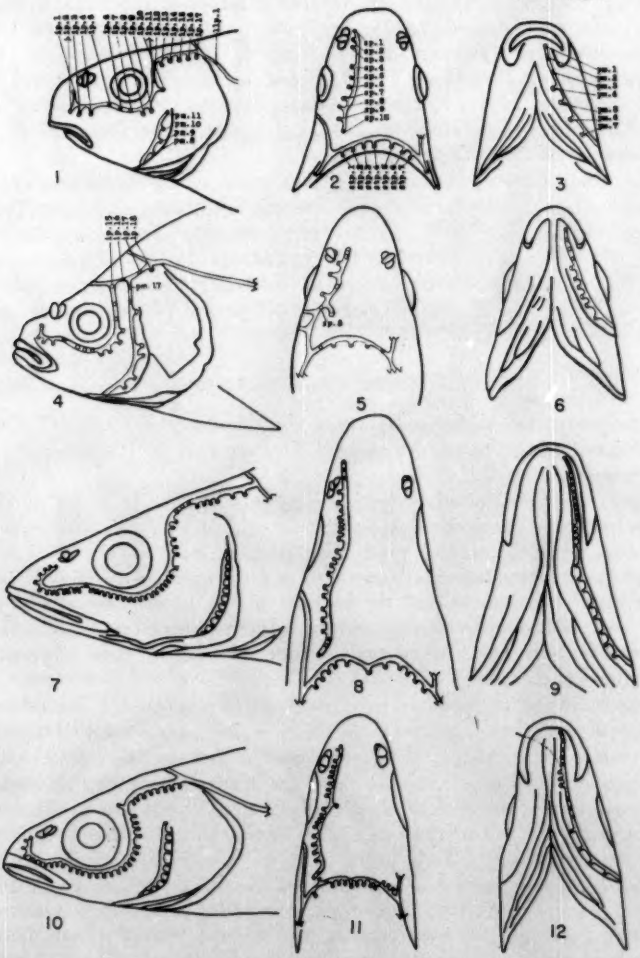
Specimens used in this study are in the collections of Cornell University, the University of Michigan Museum of Zoology, and the California Academy of Sciences.

As far as possible, adult specimens were selected. In order to observe more clearly the canals in these specimens, a slow jet of air was blown into the canals from a tapered glass tube inserted into an air hose. In this manner, the preservative was blown out, and the canals were slightly inflated which made their course and the location of the pores more clearly visible when seen with a binocular microscope. In rare instances, the canals were dissected or India ink was injected in order to observe more accurately the connections or the course of the canals.

The following observations were made on each specimen: the extent and contour of the canals, whether complete or incomplete, and if connected. Pore counts were made of the supratemporal, supraorbital, infraorbital, and preoperculomandibular canals. In most specimens, counts were also made of the supraorbital at the anterior margin, dorsal to the center and at the posterior margin of the eye. These counts for the supraorbital have not been included in the key, since they did not prove to be of value in determining specific or generic differences beyond those displayed by the total pore count for the supraorbital. Counts were taken of the infraorbital canal at a vertical projection from the rictus, the anterior margin of the eye, ventrally from the center of the eye, and at a horizontal projection posteriorly from the center of the eye, and the dorsal margin of the eye. The pore count of the mandibular canal opposite the rictus and the number of pores on the preopercle were also observed. For most of the specimens, the general curvature and completeness of the lateral line on the body, the head length, and the range of standard lengths of the series were recorded.

In an effort to obtain data on variation, a sample of ten specimens (when available) of each species was studied and semi-diagrammatic drawings made of each specimen. Three views of the head were drawn; dorsal, ventral, and

PLATE I



Figs. 1-12.—1-3. *Campostoma anomalum* (Rafinesque) No. 1 CU 15090—head length (H.L.) 21 mm; illustrating method of pore count for Cyprinidae. 1. Lateral view of the head; 2. Dorsal view of the head; 3. Ventral view of the head. 4-6. *Carassius auratus* (Linnaeus) No. 1 CU 14349—H.L. 24.5 mm; illustrating characteristics of Group Ia. All canals complete and connected. 4. Lateral view of the head. PM joins IO-pmp 17. Pores between SO and PM, and PM and ST-ip 16, ip 17, and ip 18; 5. Dorsal view of the head. SO joins IO-sp 8; ip 15; 6. Ventral view of the head. 7-9. *Ptychocheilus grande* (Ayres); No. 1 CU 18262—H.L. 33 mm; illustrating high pore count in all canals of Group IIaa. 7. Lateral view of the head. Anterior part of IO loop-shaped; 8. Dorsal view of the head. SO begins anterior to nostril and ends close to ST near

left lateral. Since the pore counts of the left side of an individual may differ from those of the right (Allis, 1889, 1904; Bramford, 1941), the pore counts were also recorded for the right side. However, the counts fell within the range of variation of that of the left side and were assumed to be the same for the purposes of this study. Thus, they have not been included in the key.

EXPLANATION OF ANATOMICAL TERMINOLOGY

Since the work of Allis (1889) on *Amia* has become the standard for studies on the lateral-line canals of fishes, the anatomical terminology used by him has been adopted as far as possible in the present study. Differences exist in the structure of the cephalic canals of *Amia* and that of the Cyprinidae, and the following alterations have been necessary. Allis starts the count for the ST[3] canal at the midline, since the ST is always complete, and there is an equal number of pores on each side of the median pore. In the present study, the count has been taken from the left side of the specimen to the right (fig. 2) with the breaks for the incomplete canals indicated by a comma. Pores common with the ST and IO have not been included unless they are on a duct facing posteriorly on the posterio-medial side of the junction of the ST and IO. Other common pores on the left side are considered the terminal pore of the IO. Common pores on the right side are eliminated, since the pore count for the right side has not been included in the key.

All counts for the SO, IO, and PM canals start anteriorly and continue posteriorly (figs. 1-3). The lateral canal of *Amia* is considered as the posterior portion of the IO in the Cyprinidae, since the SO and IO canals are not usually joined in the Cyprinidae. Therefore the IO count is taken from the anterior end of the canal to the point where the ST branches off. In the few species where the SO and PM canals may join the IO, the counts are taken to the junction with the IO. Common pores are included in the count of both canals. Pores located between the junctions of the SO and PM and between the PM and ST are included only in the IO count (figs. 4-6). To signify that the mandibular canal extends dorsally onto the preopercle, the abbreviation "PM" has been used for the Cyprinidae rather than "OM" employed by Allis.

The pores are labeled similarly to those of *Amia*. However, as a result of the dichotomous division of pores in *Amia*, there is a group of pores at the end of the primary ducts in place of the individual pore of the Cyprinidae. Thus the letter "g" has been replaced by "p" in labeling the canals of the

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junction with IO; 9. Ventral view of the head. PM extends from near symphysis of mandible to dorsal to horizontal from center of eye (figs. 7 and 9). 10-12. *Gila robusta robusta* Baird and Girard, No. 3 UMMZ 162773—H.L. 22 mm; illustrating similarity with previously listed characteristics of *Ptychocheilus grande*. 10. Lateral view of the head. 11. Dorsal view of the head. 12. Ventral view of the head.

[3] See figs. 1-12, and page 208 for explanations of abbreviations.

Cyprinidae. Aside from these differences, the anatomical terminology is essentially the same as that of Allis.

In addition to the description of the lateral-line canals of the head, a general description of the lateral line on the body has been included occasionally in the key. The curvature of the lateral line on the body has been measured relative to a line projected along the side of the body anteriorly from the usually straight caudal portion of the lateral line. If the lateral line does not curve ventrally below the projected line, it is described as slanting at a particular angle to the projected line; otherwise it is described as decurved to this line. The position and extent of the slant or curvature is described relative to the dorsal fin. In the species where a lateral band is present, a general description is given of its shape, extent, and coloration.

ABBREVIATIONS

ant.—anterior
cont.—continuous
discont.—discontinuous
IO—infraorbital canal
ip—infraorbital pore
LB—lateral band
LL—lateral-line canal
llp—lateral-line pore
loop-shaped—anterior part of infraorbital canal more or less V-shaped (fig. 7)
L-shaped—anterior part of infraorbital canal turns sharply dorsad forming a right angle (fig. 4)
OP—opercle
O-shaped—anterior part of infraorbital canal turns dorsad forming an obtuse angle (modified L-shaped)
PL—projected line
PM—preoperculomandibular canal
pmp—preoperculomandibular pore
PM 1→2 or 3→8-9—PM canal incomplete with breaks occurring at pores 2 or 3
POP—preopercle
post—posterior
SO—supraorbital canal
sp—supraorbital pore
ST—supratemporal canal
stp—supratemporal pore
ST 2 (4)—ST canal incomplete with 2 pores on each side
ST 3 (6)—ST canal incomplete with 3 pores on each side
ST 1,2-3,4-5,6—ST canal incomplete with breaks between pores 1 to 2, 3 to 4, and 5 to 6. (Comma indicates incompleteness; a dash indicates continuity)
U-shaped—anterior part of infraorbital canal more or less U-shaped with the most anterior pore lying more dorsally than the suborbital canal (fig. 10)
*(following a number)—indicates that the mode is nearest or at this number

GENERALIZED DESCRIPTION OF THE CEPHALIC LATERAL-LINE CANALS OF THE CYPRINIDAE

The supratemporal canal branches off the infraorbital canal and traverses the posterior part of the skull. It may unite with the branch from the opposite side on the mid-dorsal line or remain incomplete. If incomplete, the canals usually end slightly lateral to the mid-dorsal line, but actually they may be broken at several different places or rarely lacking on one side of individual variants (*Chrosomus, Pimephales promelas,* and *Iotichthys*). When the canal is complete, it is the only connection between the canal systems of the two sides of the head.

The supraorbital canal usually starts at a point slightly medial to the anterior border of the nostril and continues posteriorly bending sharply mediad between the nostril and the eye. It makes a semicircular curve above the eye, bending laterally near the posterior margin of the eye; and finally continues

posteriorly curving either medially or laterally as it ends anterior to the supratemporal canal. This posterior end point has been described as being anterior, equal, or posterior to a vertical projected dorsally from the dorso-posterior edge of the preopercle.

The infraorbital canal starts anterior and slightly ventral to the nostril. The anterior portion of the canal with one or several pores usually turns dorsally. If ducts are present in the preorbital portion, those on the dorsally directed part point anteriorly while the remaining ones point ventrally. Thus, the anterior part of the infraorbital canal is usually more or less L-shaped. This canal usually goes straight back toward the eye and continues posteriorly below the eye and then bends dorsally outlining the general contour of the eye. At the posterio-dorsal margin of the eye, it turns sharply posteriorly and continues as a straight line until it unites with the supratemporal and the lateral-line canal of the body.

The preoperculomandibular canal usually starts near the symphysis of the mandible or slightly posterio-laterally and continues posteriorly across the ramus of the mandible, and finally curves dorsally onto the preopercle. The canal usually extends only part way up on the preopercle (Lekander, 1949, Cyprinidae; Other teleosts: Allis, 1934; Stensiö, 1947; Holmgren and Pehrson, 1949), and in only a few species does the preopercular canal connect with the infraorbital (Allis, 1904, *Carassius*).

Drawings (figs. 1-39) have been made showing the various types of cephalic lateral-line canals found in the examined Cyprinidae.

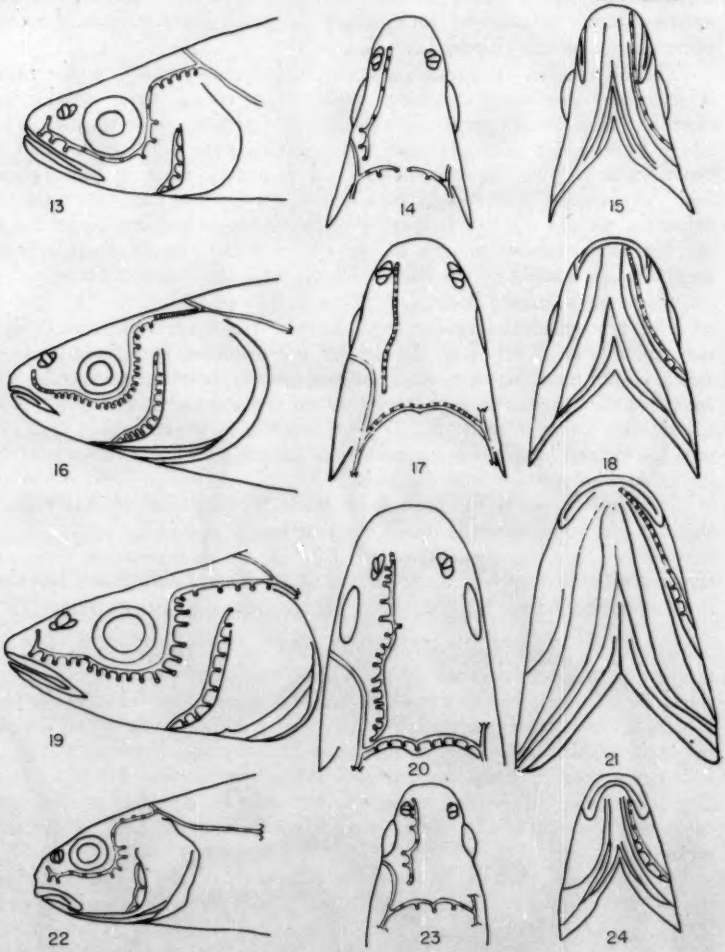
COMPARISON OF THE CEPHALIC LATERAL-LINE CANALS OF THE CYPRINIDAE WITH AMIA, VILLORA AND HOLOLEPIS, AND FUNDULUS

There are several basic differences in the extent, completeness, and connections of the cranial canals of the Cyprinidae when compared with *Amia*, the darters of the subgenus *Hololepis*, and the cyprinodont fishes of the genus *Fundulus* and related genera. The ST canal is always present and complete in *Amia* (Allis, 1889) and in *Hololepis* (Hubbs and Cannon, 1935), but it is never present in the cyprinodonts studied by Gosline (1949). In the Cyprinidae, the ST is always present, but may be complete or incomplete depending on the species, or is rarely lacking on one side as individual variation.

Allis observed that the SO and the IO canals of *Amia* join posterior to the eye and form a canal composed of branches from the SO and IO canals. This canal he called the lateral canal of the head. The lateral canal extends from the junction of the SO and IO canals to where it leaves the supraclavicula and enters the scales to form the lateral line of the body. This canal formation also exists in the darters; and in these fishes, a median coronal pore is formed by side branches of the SO canals. On the other hand, in *Fundulus*, the SO never connects with the lateral and is usually broken at several places. If the SO is complete in *Fundulus*, it replaces the posterior part of the IO of other fishes.

Among the Cyprinidae, with the exception of *Cyprinus carpio*, *Carassius auratus* (Allis, 1904), and a few unusual specimens of other species, the

PLATE 2



Figs. 13-24.—13-15. *Clinostomus elongatus,* (Cuvier and Valenciennes), No. 2 CU 15891—H.L. 16 mm; illustrating some of the characteristics of Group IVAA. 13. Lateral view of the head. Anterior part of IO L-shaped; 14. Dorsal view of the head SO begins near anterior edge of nostril and ends anterior to POP. ST always incomplete; 15. Ventral view of the head. PM from near tip of mandible to slightly ventral to horizontal from center of eye. 16-18. *Orthodon microlepidotus* (Ayres), No. 3 CU 18270—H.L. 39.5 mm; illustrating characteristics of Group IIBBB. 16. Lateral view of the head; 17. Dorsal view of the head. SO has no ducts present; all pores in canal. ST may be complete or incomplete; few ducts; 18. Ventral view of the head. PM

SO is separate and does not connect with the IO as is the case in *Amia* and *Hololepis*. There is no coronal pore present in the Cyprinidae such as is seen in the darters *Hololepis*. In minnows, the SO when complete does not assume a postorbital position such as it does in *Fundulus*.

The IO canal of *Amia* has an antorbital commissure which is not present in teleosts (Allis, 1934). The IO joins the SO in *Amia, Villora,* and *Hololepis* and is complete in *Amia, Villora,* and the more primitive species of *Hololepis* but is incomplete in the more advanced forms of *Hololepis* and in *Fundulus*. With the few exceptions previously mentioned, the IO does not join the SO in the Cyprinidae, but it may be complete or incomplete depending on the species. However, in the Cyprinidae with an incomplete IO canal, the breaks are not as extensive as in the cyprinodonts which have no closed canal between the anterior and posterior portions of the IO.

The operculomandibular canal of *Amia* is complete and joins the IO posterior to the junction of the SO and IO. The operculomandibular canal is also complete in *Hololepis,* but it does not connect with the IO. In the cyprinodonts examined by Gosline (1949), the preopercular and mandibular canals are connected only in the genus, *Profundulus,* and the mandibular canal is often lacking in other species. However, the preopercular canal appears to extend quite far dorsally on the preopercle.

In the Cyprinidae studied to date, the PM canal joins the IO canal only in *Cyprinus* and *Carassius* (Allis, 1904) and occasionally in *Notemigonus* and *Lavinia*. The cyprinid PM canal may be complete or incomplete depending on the species, but the mandibular is never wholly lacking as in some cyprinodonts. The dorsal height of the preopercular canal on the preopercle is variable, and it may end just ventral to the IO as it does in *Notemigonus* and *Lavinia,* which is similar to the situation observed in *Abramis* and *Leuciscus* by Lekander (1949). In many species of Cyprinidae, however, the PM canal extends only part way up on the preopercle as noted in *Phoxinus* (Lekander, 1949). Actually, the preopercular canal may be lacking or very short as in *Tiaroga cobitis*.

CEPHALIC LATERAL-LINE CHARACTERS OF SOME SPECIES AND SUBSPECIES OF CYPRINIDAE ARRANGED IN KEY FORM

Ia. SO joins IO; all four canals complete (usually) and connected. (Old World forms introduced and widely established in North America.)

A. IO count 22-25 ..... *Cyprinus carpio* Linnaeus

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extends from near tip of mandible to near to horizontal from top of eye (figs. 16 and 18). 19-21. *Pogonichthys macrolepidotus* (Ayres), No. 1 CAS II:16:1949—H.L. 39 mm; illustrating some of the characteristics of Group IIIA. All four canals complete; usually with higher pore count for SO and PM canals than Group IIIAA. 19. Lateral view of the head; 20. Dorsal view of the head. SO ends close to ST; 21. Ventral view of the head. PM extends from near symphysis of mandible to near to horizontal from top of eye. 22-24. *Agosia chrysogaster* Girard, No. 2 CU 18205—H.L. 12.5 mm; illustrating some of the characteristics of Group IIIAA. All four canals complete but usually with lower pore count for SO and PM canals than Group IIIA. 22. Lateral view of the head; 23. Dorsal view of the head, SO ends anterior to POP; 24. Ventral view of the head. PM extends from one-third to one-half of mouth to ventral to horizontal from center of eye.

AA. IO count 16-18 ..... *Carassius auratus* (Linnaeus) (figs. 4-6)

Ib. SO not joining IO (next consider five groups numbered II through VI).

II. ST both complete and incomplete; PM 18-54, occasionally 13-17 in *Notemigonus, Gila orcuttii,* and *Gila nigrescens.*

A. SO not anterior to nostril; PM joins or nearly joins IO. *Notemigonus crysoleucas* (Mitchill)—IO count 18-23; greatly decurved LL.

AA. SO anterior to nostril and extends close to ST; PM ends dorsal to horizontal from center of eye (B-BBBB)

B. IO anterior part forms loop—dorsal part 6-9 pores; IO count 50-66..... ..... *Ptychocheilus lucius* Girard

BB. IO anterior part forms loop—dorsal part 4-5 pores; IO count 37-48; PM count 29-38 ..... *Ptychocheilus grande* (Ayres) (figs. 7-9)

BBB. IO anterior part forms loop—dorsal part 1-4* pores; IO count 35-40; PM count 22-25 .....*Gila robusta robusta* Baird and Girard (figs. 10-12)

BBBB. IO anterior part forms more U-shaped loop—dorsad part 1-3 pores; IO count 26-31 . . . *Ptychocheilus umpquae* Snyder—ST 11, SO 17-18, IO 26-30, PM 21-23; *Gila robusta robusta* Baird and Girard X *Gila robusta intermedia* (Girard) —ST 9-11, SO 14-17, IO 26-31, PM 18-24

AAA. SO rarely anterior to nostril; PM dorsal to center of eye (B-BBB)

B. PM count 13-25 (*Siphateles* PM count 19-30—bb)

C. ST 11-12 ..... *Gila crassicauda* (Baird and Girard)

CC. ST 6-10

D. IO always incomplete—18-27* ..... *Gila bicolor* (Girard)

DD. IO always complete—17-33 (22*) (IO pore count for *Gila orcuttii* and *Gila nigrescens* 17-23; *Siphateles* 24-33—bb.) . . . *Gila atraria* (Girard)— PM 18-33; LL cont. and decurved to beyond dorsal fin; faint LB; *Gila orcuttii* (Eigenmann and Eigenmann)—PM 14-19; LL cont. or discont. and slants 20° angle to under back of dorsal fin; LB dark caudally from anterior to dorsal fin; *Gila nigrescens* (Girard)—PM 13-17; LL cont. and slightly decurved to beyond dorsal fin; LB slightly higher anteriorly and darker posterior to the origin of dorsal fin.

BB. PM count 19-30; ducts on SO and ST; IO count 24-33 and complete or incomplete; POP count 5-9 . . . *Siphateles obesus pectinefer* (Snyder)—ST 8-12, SO 10-14, IO 24-28, PM 20-25; *Siphateles obesus oregonensis* (Snyder)—ST 10-13, SO 12-15, IO 25-29, PM 21-26; *Siphateles mohavensis* (Snyder)—ST 10-12, SO 13-16, IO 24-28, PM 19-22; *Siphateles bicolor bicolor* (Girard)—ST 11-15, SO 13-17, IO 26-33, PM 23-30.

BBB. PM count 27-34; no ducts on SO and few on ST; IO count usually 36-48 (31-48); POP count 9-15 . . . *Orthodon microlepidotus* (Ayres) (figs. 16-18)

III. All four canals complete (usually).

A. SO count usually 12-22 and ends close to ST; PM count usually 16-24 (exception *Acrocheilus*).

B. PM ends near top of eye

C. SO count 14-22 .....*Pogonichthys macrolepidotus* (Ayres) (figs. 19-21)

CC. SO count 11-15 (12*) .....*Lavinia exilicauda* Baird and Girard

BB. PM ends equal to or slightly dorsal to horizontal from center of eye

C. IO 8-10 pores to rictus; PM count 18-21 (20*) . . . *Mylopharodon conocephalus* (Baird and Girard)

CC. IO 6-7 pores to rictus; PM count 14-20 (17*) . . . *Mylocheilus carinum* (Richardson)

CCC. IO 7-9 pores to rictus; PM count 13-18 (15*) . . . *Acrocheilus alutaceus* (Agassiz and Pickering)

AA. SO count usually 7-11; PM count 6-15

B. PM ends equal to horizontal from center of eye (rarely ventral)

C. ST 8-10; PM 13-15 . . . *Algansea affinis* (Regan)

CC. ST 4-7 or PM 9-12 (rarely 14)

D. PM 3+-5 pores to rictus . . . *Hesperoleucus symmetricus* (Baird and Girard) —ST 5-8, SO 8-12, IO 14-17, PM 10-12; *Hesperoleucus symmetricus venustus* Snyder—ST 4-7, SO 10-12, IO 16-20, PM 12-14 (13*); *Hesperoleucus symmetricus symmetricus* (Baird and Girard)—ST 5-6, SO 7-10, IO 15-19, PM 10-12; *Hesperoleucus symmetricus navarroensis* Snyder—ST 5*-8, SO 8-10, IO 16-21, PM 11*-14.

DD. PM 1-2+ pores to rictus . . . *Exoglossum maxillingua* (Le Sueur)—ST 4-8, SO 8-11, IO 15-18, PM 9-12; *Parexoglossum laurae* Hubbs—ST 5-7, SO 9-10, IO 13-17, PM 9-11.

BB. PM ends ventral to horizontal from center of eye (usually-lower edge of eye)

C. PM count 9-13 . . . *Campostoma anomalum* (Rafinesque) (figs. 1-3) . . . —ST 5-9, SO 8-10, IO 12-19 (16*), PM 9-13 (10*); *Agosia chrysogaster* Girard—(figs. 22-24) ST 5-7, SO 7-10, IO 14-16 (15*), PM 9-10 (9*)

CC. PM count 6-7 . . . *Phenacobius teretulus* Cope

IV. ST both complete and incomplete, other canals usually complete; PM count 8-17, Rarely 18 in *Richardsonius balteatus.*

A. IO anterior part usually extends far forward and slants ventrad; except for (*Couesius*) and sometimes (*Nocomis*)

B. IO two to five ducts grouped over mouth

C. IO count 18-22 . . . *Hybopsis* (*Extrarius*) *aestivalis tetranemus* (Gilbert)—(figs. 25-27) ST both complete and incomplete 5-6, SO 8-11, IO 18-22, PM 11-15; *Hybopsis* (*Extrarius*) *aestivalis hyostomus* (Gilbert)—ST always complete 3-7; SO 8-10, IO 18-21, PM 10-13

CC. IO count usually 11-16, rarely 18-19 . . . *Hybopsis* (*Macrhybopsis*) *gelidus* (Girard)—ST always complete 3-6, SO 8*-9, IO 14-19, PM 9-12 (10*); *Hybopsis* (*Macrhybopsis*) *meeki* Jordan and Evermann—ST both complete and incomplete 3-6, SO 7-8*, IO 11-16, PM 10-12

BB. IO two to five ducts rarely grouped over mouth, IO count 15-19

C. ST count 7*-10 . . . *Hybopsis* (*Erimystax*) *dissimilis* (Kirtland)—ST always complete 7*-10, SO 9-10, IO 15-16, PM 8-11

CC. ST usually 5-6, rarely 7-8 . . . *Hybopsis storerianus* (Kirtland)—ST both complete and incomplete 5-8, SO 9-11, IO 16-19, PM 10-17 (13*); *Hybopsis* (*Couesius*) *plumbeus* (Agassiz)—ST both complete and incomplete 4-7, SO 8-10, IO 15-18, PM 9-12; *Hybopsis* (*Nocomis*) *micropogon* (Cope) ST usually complete 5-6, SO 7-9, IO 16-17, PM 8-9

AA. IO anterior part L-shaped and does not slant ventrad (B-BBB)

B. ST always incomplete . . . *Rhinichthys atratulus* (Hermann)—ST 5-7, SO 8-10, IO 15-19, PM 8-11 (10*); *Clinostomus elongatus* (Kirtland) (figs. 13-15) ST 4-8, SO 8-9, IO 15-17, PM 11-16 (15*); *Clinostomus vandoisulus* (Cuvier and Valenciennes)—ST 5-6, SO 8-9, IO 12-15, PM 11-13 (12*)

BB. ST always complete

C. IO count 17-20 (18*) . . . *Richardsonius balteatus* (Richardson)—ST 6-9, SO 9-15, IO 17-20 (18*), PM 11-18

CC. IO count 15-16 . . . *Richardsonius egregius* (Girard)—ST 5-6, SO 8-10, IO 16, PM 12-14 (13*); *Rhinichthys osculus* (Girard)—ST 5-7, SO 8-10, IO 15-16, PM 9-13; *Rhinichthys cataractae* (Valenciennes)—ST 4-5*, SO 8-9, IO 15-16, PM 8-10

BBB. ST usually complete; IO count 13-14 . . . *Dionda nubila* (Forbes)—ST 4-7, SO 8-11, IO 13-14, PM 10-11

V. ST usually incomplete (except for *Notropis cornutus*. ST may be complete or incomplete); other canals usually complete (except for incomplete IO in *Notropis umbratilis cyanocephalus* and *Ericymba buccata*). (A-AAA)

A. ST count usually 7-9 (5-9), rarely 3(6)
B. IO count 21-24 . . . *Semotilus* (*Leucosomus*) *corporalis* (Mitchill)—ST 5-8*

BB. IO count 16-19 (18*) . . . *Semotilus* (*Margariscus*) *margarita margarita* (Cope)—ST 5-9 (8*); *Semotilus* (*Margariscus*) *margarita nachtriebi* (Cox)—ST 6-8*

AA. ST count usually 3(6) (4-11); 5 or 7 if complete; IO 13-19 (16*) (B-BBB)

B. PM usually 13-16, rarely 11 . . . *Semotilus atromaculatus atromaculatus* (Mitchill)—PM 13*-14; *Semotilus atromaculatus thoreauianus* (Jordan)—PM 11-16*

BB. PM count usually 11-13, rarely 10 or 13 . . . *Hybognathus nuchalis regius* Girard—ST 4-6, SO 8, IO 13-17 (15*), PM 10-13 (11*); *Notropis volucellus volucellus* (Cope)—IO 15-16; *Notropis cornutus* (Mitchill) (figs. 28-30)—IO 12-15 (14*); *Notropis coccogenis* (Cope)—IO 13-14*

BBB. PM count usually 9-10, rarely 11 . . . *Notropis chlorocephalus* (Cope); *Notropis analostanus* (Girard)

AAA. ST count usually 2(4) (2-6); 3 if complete

B. IO usually complete 13-17, rarely incomplete

C. SO usually 9, rarely 8; PM 12-14 . . . *Notropis atherinoides* Rafinesque

CC. SO usually 7-8, rarely 9; PM usually 9-11, rarely 12-14 . . . *Notropis scabriceps* (Cope)—LL cont. slants 10° angle one-third distance to dorsal fin; *Notropis ardens* (Cope) LL cont. decurved to under dorsal fin; *Notropis ornatus* (Girard) LL cont. slightly decurved to under back of dorsal fin; *Hybognathus placita* (Girard) LL cont. slants 10° angle one-third distance to dorsal fin

BB. IO always incomplete 12-16

C. IO always incomplete near dorso-posterior margin of eye . . . *Notropis umbratilis cyanocephalus* (Copeland)—ST 2*-5; PM 11*-13

CC. IO always incomplete in postorbital region or most of postorbital region may be lacking . . . *Ericymba buccata* Cope—ST 4*-5; PM 9*-10

VI. ST and PM canals usually incomplete; SO and IO both complete and incomplete

A. PM starts near edge of lower jaw

B. PM ends usually dorsal to lower edge of eye (C-CCC)

C. IO always complete and anterior part slants ventrad . . . *Plagopterus argentissimus* Cope (figs. 31-33)—silvery LB posterior to origin of dorsal fin, ST 5-7, SO 7-11, IO 18-21, PM 10-14

CC. IO either complete or incomplete and anterior part L-shaped . . . *Lepidomeda vittata* Cope—ST 5-8, SO 7-10, IO 14-21, PM 9-14; *Meda fulgida* Girard ST 3-9, SO 8-11, IO 14-21, PM 11-14; *Aztecula vittata lermae* (Evermann and Goldsborough) ST 7-10, SO 9-12, IO 14-19, PM 11-14

CCC. IO always incomplete with temporal portion lacking or short canal present . . . *Hybopsis* (*Oregonichthys*) *crameri* (Snyder) (figs. 34-36)—ST 6-13, SO 4-13, IO 15-23, PM 13-18

BB. PM ends usually ventral to lower edge of eye

C. Two lateral bands . . . *Chrosomus* (*Pfrille*) *neogaea* (Cope)—ST 2-6, SO 8-10, IO 19-21 (20*), PM 12-15; *Chrosomus eos* (Cope)—ST 3-6, SO 7-11, IO 14-20 (18*), PM 11-14

CC. One lateral band

D. Lateral line complete—usually straight back from OP or very slightly decurved . . . *Opsopoeodus emiliae* Hay—LL cont. or discont., ST 2-7, SO 7-12 (8*), IO 14-18, PM 9-12; *Pimephales* (*Hyborhynchus*) *notatus* (Rafinesque)—LL cont. ST 4-5, SO 9-11, IO 16-17, PM 8-9*; *Pimephales* (*Ceratichthys*) *perspicuus* (Girard) — LL cont., ST 2-6, SO 9, IO 14-17, PM 9-10*; *Pimephales* (*Ceratichthys*) *vigilax* (Baird and Girard)—LL cont., ST 4, SO 9, IO 16, PM 9; *Pimephales* (*Ceratichthys*) *tenellus* (Girard)—LL cont., ST 4, SO 9-11, IO 14-17, PM 8-10

DD. Lateral line incomplete

E. SO ends at posterior margin of eye . . . *Pimephales promelas* Rafinesque —LL discont. ends ant. to under dorsal fin; ST 1-6, SO 5-9 (7*), IO 14-17, PM 7-11

EE. SO ends posterior to posterior margin of eye . . . *Hemitremia flammea* (Jordan and Gilbert)—LL cont. ends ant. to dorsal fin

AA. PM starts at or posterior to rictus

B. SO count 8-10 . . . *Tiaroga cobitis* Girard—LL cont. from top OP slants 10° angle to under dorsal fin

BB. SO count 3-6 (over posterior portion of eye); IO not anterior to eye . . . *Iotichthys phlegethontis* (Cope) (figs. 37-39)—LL cont. or discont. and ends near OP.

DISCUSSION

GENERIC CHARACTERISTICS

While there are features of the cephalic lateral-line canals of the Cyprinidae that are characteristic of certain groups, it is impossible to indicate definite phylogenetic relationships based solely on this criterion. Also, generic divisions as presently recognized are often quite arbitrary, and the delineation of the lateral-line characters difficult to determine at the generic level. Furthermore, the generic summary presented in table 1 and also in key form is valid only for those groups in which all species were examined. However, the various genera and species can be placed within seemingly natural groups even though not always indicative of phylogeny.

TABLE 1.—Range of pore counts of the cephalic lateral-line canals of some genera of Cyprinidae.

Genera	Range of Variation of Pore Count			
	ST	SO	IO	PM
Cyprinus	9-12	12-16	22-25	19-22
Carassius	4- 7	7-10	16-18	14-19
Notemigonus	7-11	10-14	18-23	16-23
Ptychocheilus	10-27	17-30	26-66	21-54
Gila	6-14	9-22	17-40	13-25
Siphateles	8-15	10-17	24-33	19-30
Orthodon	12-21	16-22	31-48	27-34
Pogonichthys	8-11	14-22	24-27	19-23
Lavinia	7-11	11-15	20-26	20-24
Mylopharodon	10-13	14-18	24-30	18-21
Mylocheilus	9-11	13-16	23-29	14-20
Acrocheilus	7-15	10-15	21-28	13-18
Algansea	8-10	9-12	16-23	13-15
Hesperoleucas	4- 8	7-12	14-21	10-14
Exoglossum	4- 8	8-11	15-18	9-12
Parexoglossum	5- 7	9-10	13-17	9-11
Campostoma	5- 9	8-10	12-19	9-13
Agosia	5- 7	7-10	14-16	9-10
Phenacobius	5- 8	8-10	12-16	6- 7
Hybopsis	3-13	7-13	11-23	8-18
Richardsonius	4- 9	8-15	12-20	11-18
Rhinichthys	4- 7	8-10	15-19	8-13
Clinostomus	4- 8	8- 9	12-17	11-17
Dionda	4- 7	8-11	13-14	10-11
Semotilus	5-11	8-12	13-24	10-17
Hybognathus	3- 6	8	13-17	9-13
Notropis	2- 9	7-10	12-17	9-14
Ericymba	4- 6	8-10	12-15	9
Plagopterus	5- 7	8-11	18-21	10-14
Lepidomeda	5- 8	7-10	14-21	9-14
Meda	3- 9	8-11	14-21	11-14
Aztecula	7-10	9-12	14-19	11-14
Chrosomus	2- 6	7-11	14-21	11-15
Opsopoeodus	2- 7	7-12	14-18	9-12
Pimephales	2- 6	6-11	14-17	7-11
Hemitremia	2- 6	6- 9	13-17	10-12
Tiaroga	3- 7	7-10	14-17	5-11
Iotichthys	1- 7	3- 6	3-12	4-10

The genera are listed according to the main Group headings in table 1; and whenever possible, generic characteristics or differences between related genera are given in the generic key. From the sequence of the Groups, implications of developmental trends are indicated. From table 1, and the keys to the genera and species, it will be noted that the Groups have been arranged, as far as possible, according to the completeness and extent of the canals of the examined species. Within each of these Groups there is a tendency toward a decrease in the pore count and a subsequent shortening of the SO and PM canals. Since there is not a simultaneous decrease in the pore count of the four cranial canals, emphasis in the treatment has been placed on the PM

and SO canals, which are usually free and vary in length. As far as possible, these changes in length have been incorporated into the key.

Some characteristics of the cephalic lateral-line canals of some genera of Cyprinidae arranged in key form. Range of variation of pore counts is given in table 1. Five alternatives are to be considered below under 3 and three under 18. The exceptions noted by the term "usually" as used here are for individuals rather than for species or genera.

1a. SO joins IO; all four canals are complete (usually) and connected 2
1b. So not joining IO 3
2a. Pore counts high (table 1) ..... *Cyprinus*
2b. Pore counts low ..... *Carassius*
3a. ST both complete and incomplete; PM count usually 18-54 4
3b. All four canals (usually) complete 8
3c. ST both complete and incomplete, other canals usually complete; PM count usually 8-17 13
3d. ST usually incomplete; other canals usually complete 15
3e. ST and PM usually incomplete; other canals both complete and incomplete..... 16
4a. PM joins or nearly joins IO ..... *Notemigonus*
4b. PM never joins IO 5
5a. Anterior part of IO looped or U-shaped; 2-3 pores of SO lie anterior to nostril (all canals complete) ..... *Ptychocheilus*
5b. Anterior part of IO usually U-shaped; SO may or may not extend anterior to nostril 6
6a. Anterior part of IO occasionally loop-shaped and IO count 17-40; ducts present to SO pores ..... *Gila*
6b. Anterior part of IO U- or L-shaped; SO rarely extends anterior to nostril..... 7
7a. Few or no ducts present to SO pores; IO count usually 36-48..... *Orthodon*
7b. Ducts present to SO pores; IO count 24-33 ..... *Siphateles*
8a. SO count is usually 12-22 and ends close to ST; PM count usually 16-24 (except *Acrocheilus*) 9
8b. SO count usually 7-11; PM count 6-15 10
9a. PM ends near dorsal edge of eye ..... *Pogonichthys* and *Lavinia*
9b. PM ends at or slightly dorsal to center of eye ..... *Mylopharodon, Mylocheilus, Acrocheilus*
10a. SO ends close to ST; PM ends at or near center of eye, 3+ - 5 pores anterior to rictus ..... *Algansea, Hesperoleucus*
10b. SO ends near the posterior edge of POP 11
11a. PM rarely ends below the center of eye, 1-2+ pores anterior to rictus..... *Exoglossum, Parexoglossum*
11b. PM ends below the center of eye 12
12a. PM count 9-13 ..... *Campostoma, Agosia*
12b. PM count 6-7 ..... *Phenacobius*
13a. IO extends far forward and slants downward..... *Hybopsis*
13b. Anterior part of IO is L-shaped 14
14a. IO count usually 15-20..... *Richardsonius, Rhinichthys*
14b. IO count 13-14 (ST usually complete) ..... *Dionda*
15a. IO usually complete, postorbital canal present..... *Semotilus, Hybognathus, Notropis*
15b. IO postorbital canal usually absent or with a break..... *Ericymba*
16a. PM begins near edge of lower jaw anterior to rictus 17
16b. PM begins at or posterior to the rictus 20
17a. PM ends above a line projected horizontally from the lower edge of the eye..... 18

NOTE: Three alternatives under 18

17b. PM usually ends below a line projected horizontally from the lower edge of the eye 19
18a. IO always complete and slants ventrad anteriorly ..... *Plagopterus*
18b. IO complete or incomplete and L-shaped ..... *Lepidomeda, Meda, Aztecula*
18c. IO always incomplete; the temporal section is short or absent; PM count 13-18 ..... *Hybopsis* (*Oregonichthys*)
19a. PM count 11-15 (mode 12) ..... *Chrosomus*
19b. PM count 7-12 (mode 9) . . . *Opsopoeodus, Pimephales* (LL complete except for *Pimephales promelas*), *Hemitremia* (LL incomplete ends anterior to dorsal fin)
20a. SO count 7-10; IO count 14-17 ..... *Tiaroga*
20b. SO count 3-6; IO count 3-12 ..... *Iotichthys*

Naturally, there are exceptions to this arrangement. In Group II, *Gila* follows *Ptychocheilus* rather than *Orthodon*, because of the similarity of the anterior part of the IO and SO in *Ptychocheilus* and some of the species of *Gila*. *Gila* is a large and widely distributed genus, which is composed of species quite variable in lateral-line characteristics. Thus, the wide range of variation in pore count and in characteristics of the canals overlaps those of the neighboring genera, *Ptychocheilus* and *Siphateles*.

In Group III, *Lavinia* has been placed before the remaining genera of this group, because of the greater height and higher pore count of the PM canal. Also, with the exception of the genus *Acrocheilus*, Group III can usually be subdivided on the basis of pore counts for the SO and PM canals. *Campostoma* of Group III appears to have a somewhat higher pore count than *Exoglossum* and *Parexoglossum*, but actually the preopercular canal is usually shorter.

Group IV contains genera, composed of species having variable lateral-line characteristics, and thus the adherence to a sequence of decreasing pore count has not been maintained in the case of *Hybopsis storerianus*.

Group V, however, is arranged according to decreasing pore count. Thus *Semotilus* intervenes between *Dionda* (Group IV bbb, ST usually complete) and *Notropis* (Group V, ST usually incomplete), although the latter two are probably more closely related.

The ST and PM canals of the genera of Group VI are usually incomplete. In this Group, the SO of *Plagopterus, Lepidomeda*, and *Meda* is rarely incomplete. The IO of *Plagopterus* is always complete, but it is occasionally incomplete in the other two genera; usually with only one break. The SO of *Aztecula* is usually incomplete and occasionally the IO is incomplete. The SO and IO canals of *Hybopsis* (*Oregonichthys*) are always incomplete; often with more than one break. The SO and IO canals of *Chrosomus, Opsopoeodus, Pimephales*, and *Hemitremia* may be complete or incomplete with one or more breaks. The maintenance of a relatively high pore count in the genera *Hybopsis* (*Oregonichthys*) to *Hemitremia;* particularly for the IO canal may be correlated with the incompleteness of the canal. The lower PM count of *Tiaroga* and *Iotichthys* may be correlated with the shortness of the canal. The SO and IO canals of *Iotichthys* are also very short.

From the previous discussion, it is evident that the cyprinid genera examined in the present study can be placed within Groups on a basis of lateral-line characteristics. Within these Groups, certain distinctive generic char-

acteristics are evident in comparing genera; such as *Cyprinus* and *Carassius; Ptychocheilus* and *Gila; Gila* and *Siphateles; Orthodon, Phenacobius, Hybopsis* (including *Macrhybopsis, Extrarius, Erimystax,* and occasionally *Nocomis*), *Plagopterus, Hybopsis* (*Oregonichthys*), *Tiaroga* and *Iotichthys.* Occasionally genera can be separated by using several lateral-line characteristics. For the most part, however, the differences are so slight or gradual that generic characteristics are masked.

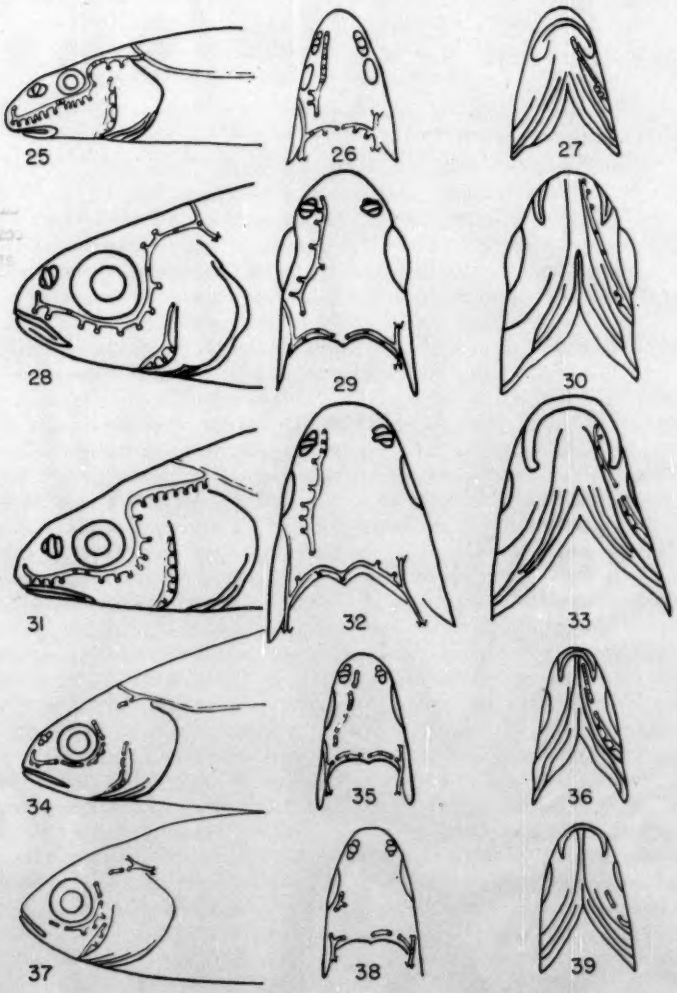
SPECIFIC CHARACTERISTICS

Specific characteristics and differences can be ascertained from the key. However, several interesting aspects will be mentioned here. (1) All three species of *Ptychocheilus* studied can be separated on a basis of pore count, with *P. lucius* having an especially high pore count. (2) Variability of lateral-line characters was observed in the six species of *Gila* studied. Some, such as *Gila r. robusta,* resemble *Ptychocheilus* with a high multiplication of pores, looped IO, and complete canals. Others, such as *G. atraria,* have a lower pore count and U-shaped IO like *Siphateles.* (3) Of the three species of *Siphateles* studied, a slight difference in PM count exists between *S. mohavensis* (19-22) and *S. b. bicolor* (23-30). (4) The six (?) subgeneric groups of *Hybopsis,* with the exception of *Couesius,* may show slight differences. (5) *Richardsonius balteatus* and *R. egregius* show a slight difference in IO count, and both can be separated from *Clinostomus,* which has an incomplete ST. (6) *Rhinichthys osculus* and *R. cataractae* have a complete ST, but *R. atratulus* has an incomplete ST. (7) *Semotilus corporalis* can be distinguished by a higher IO count from *S. margarita* and *S. atromaculatus,* but the latter two species are separated by only a slight variance in pore count of the ST and IO canals. (8) The ST count of *Hybognathus nuchalis regius* is usually 5 or 6, rarely 2 (4); *H. placita* is always 2 (4). (9) The ten species of *Notropis* examined, which represent several subgenera, can be sub-divided into rather indefinite groups. However, specific differences are not evident except for *Notropis umbratilis cyanocephalus,* which has an incomplete IO with a break near the dorso-posterior margin of the eye. Bailey (1951) described the IO canal for *Notropis volucellus* as always complete, and for *N. buchanani* as wholly undeveloped or (rarely) a short section of tube. (10) There is apparently no specific difference of lateral-line characteristics between *Chrosomus eos* and *C.* (*Pfrille*) *neogaea.* (11) *Pimephales promelas* can be distinguished from *P.* (*Hyborhynchus*) *notatus* and *P.* (*Ceratichthys*) *perspicuus, tenellus,* and *vigilax,* since the SO ends above the posterior margin of the eye in *P. promelas* and extends posterior to it in all the rest.

SUBSPECIFIC CHARACTERISTICS

Subspecies of four species, *Siphateles obesus, Hesperoleucus symmetricus, Semotilus atromaculatus* and *Semotilus margarita* were studied. No significant subspecfic differences were observed for any of the following: *Siphateles obesus pectinifer* and *S. obesus oregonensis; Hesperoleucus s. symmetricus, H. s. venustus,* and *H. s. navarroensis; Semotilus m. margarita* and *S. m. nachtriebi; S. a. atromaculatus* and *S. a. thoreauianus.*

PLATE 3



Figs. 25-39.—25-27. *Hybopsis* (*Extrarius*) *aestivalis tetranemus* (Gilbert), No. 5 CU 17903—H.L. 10 mm; illustrating some of the characteristics of Group IVA. 25. Lateral view of the head. IO extends far anterior and slants ventrad as in most *Hybopsis*; 3 to 5 ducts over mouth in (*Extrarius*); 26. Dorsal view of the head. SO ends anterior to equal to POP. ST may be complete or incomplete; 27. Ventral view of the head. PM extends from one-third of mouth to ventral to equal to horizontal from center of eye (figs.

SUMMARY

The present comparative study was undertaken to gain knowledge of the characteristics of the cephalic lateral-line canals in the North American Cyprinidae and to determine the level of differentiation and relationships based on these characters. The lateral-line characteristics in eighty-three species were determined, and a key was constructed. Several generic and specific differences were observed, but no subspecific difference could be found. Along with other studies, a knowledge of cephalic lateral-line characters will contribute toward an ultimate understanding of the relationships within this large family of fishes.

REFERENCES

ALLIS, E. P. 1889—The anatomy and development of the lateral-line system in *Amia calva*. J. Morph. 2:463-566.

ALLIS, E. P. 1903—The lateral sensory system in the Muraenidae. Int. Mschr. Anat. Physiol. 20:125-170.

——— 1904—Sensory canals and related bones in fishes. Ibid. 21:401-502.

——— 1934—Concerning the course of the latero-sensory canals in recent fishes, prefishes and Necturus. J. Anat., Paris 68:361-415.

*ANDRES, A. 1899—Anatomia della Tinca con referenza ad altre Ciprinidae. Milano.

BAILEY, R. 1951—Key to the Species and Subspecies of Notropis. Iowa Fish and Fishing, Iowa State Conservation Commission, Des Moines.

BRAMFORD, T. W. 1941—The lateral line and related bones of the herring *Clupea harengus*. Ann. and Mag. Nat. Hist. (ser. 11) 8:414-438.

25-27). 28-30. *Notropis cornutus* (Mitchill), No. 5 CU 18111—H.L. 15 mm; illustrating some of the characteristics of Group VAA. 28. Lateral view of the head. IO—anterior part L-shaped; therefore differs from IO of most of *Hybopsis* (Figs. 25-27); 29. Dorsal view of the head. SO ends anterior to POP. ST may be complete or incomplete (usually incomplete) for rest of Group V; 30. Ventral view of the head. PM extends from near tip of mandible to ventral to horizontal from center of eye. 31-33. *Plagopterus argentissimus* Cope, No. 3 UMMZ 124770—H.L. 14 mm; illustrating some of the characteristics of Group VIA. 31. Lateral view of the head. IO anterior part extends far anterior and slants ventrad; 32. Dorsal view of head. SO ends anterior to posterior to POP; 33. Ventral view of the head. PM extends from about one-half of mouth to slightly ventral to equal to horizontal from center of eye; usually incomplete 1 → 4 or 6 → 12-14 with break near posterior margin of mouth (figs. 31 and 33). 34-36. *Hybopsis* (*Oregonichthys*) *crameri* (Snyder), No. 2 CU (Exch. C.E. Bond)—H.L. 8.5 mm; illustrating some of the characteristics of Group VICCC. 34. Lateral view of the head. IO broken into many sections; lacking or short canal above POP; 35. Dorsal view of head. SO incomplete and ends just behind eye. ST incomplete and may be broken at several places; 36. Ventral view of the head. PM extends from near tip of mandible to ventral to horizontal from center of eye; incomplete 1 → 4 or 6 → 13-18 with break near rictus. 37-39. *Iotichthys phlegethontis* (Cope), No. 1 UMMZ 141434—H.L. 8.5 mm; illustrating some of the characteristics of Group VIAA. 37. Lateral view of the head. IO usually incomplete and does not extend anterior to eye and often lacking in temporal region; 38. Dorsal view of the head. SO present only over posterior part of eye; very short canal 3-6 pores. ST incomplete and broken irregularly; 39. Ventral view of the head. PM complete or incomplete and usually starts at or posterior to rictus and extends to ventral to horizontal from center of eye.

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* Not seen.

COLLINGE, W. E. 1895—On the Sensory Canal System of Fishes. Teleostei-Suborder Physostomi. Proc. Zool. Soc., Lond.: 274-298.

——— 1895a—On the sensory and ampullary canals of Chimaera. Ibid.: 878-890.

DAGET, J. 1950—La ligne latérale: Ses fonctions. L'Année Biol. 53-54:ser. 3, 304-322.

DEVILLERS, CH. 1944—Le Système Sensorial Céphalique du Gardon (Leuciscus rutilus L.) Bull. Soc. Zool. Fr. 68-69:94-97.

EWART, J. C. 1891—The lateral sense organs of elasmobranchs. I. The sensory canals of *Laemargus*. Trans. Roy. Soc. Edinb. 37:59-86.

——— AND J. C. MITCHILL 1891—On the Lateral Sense Organs of Elasmobranchs. II. The Sensory Canals of the Common Skate *Raia batis*. Ibid. 37:87-106.

FUCHS, S. 1895—Uber die Function der unter der Haut liegenden canalsysteme bei den Selachiern. Pflüg. Arch. ges. Physiol. 59:454-489.

GARMAN, S. 1888—On the lateral canal system of the Selachia and Holocephali. Bull. Mus. Comp. Zool. 17(2):57-119.

GOSLINE, W. A. 1949—The sensory canals of the head in some cyprinodont fishes, with particular reference to the genus *Fundulus*. Occ. Papers Mus. Zool. No. 519, Univ. of Mich., 1-17.

HERRICK, C. J. 1927—An introduction to neurology. Philadelphia and London: Saunders and Co.

HOFER, B. 1908—Studien über die Hautsinnesorgane der Fische. Ber. Kgl. Biol. Versuchsstat. München 1:115-164.

HOLMGREN, N. 1942—General Morphology of the Lateral Sensory Line system of the head in fish. Kungl. Svenska Vetenskaps. Akad. Handl. 20(ser. 3):1-46.

——— AND T. PEHRSON 1949—Some remarks on the ontogenetical development of the sensory lines on the cheek in fishes and amphibians. Acta Zool., Stockh. 30:249-314.

HUBBS, C. L. AND M. D. CANNON 1935—The darters of the genera *Hololepis* and *Villora*. Misc. Publ. No. 30, Mus. of Zool., Univ. of Mich., 1-93.

——— B. W. WALKER, AND R. E. JOHNSON 1943—Hybridization in nature between species of American cyprinodont fishes. Contrib. Lab. Vert. Biol., Univ. of Mich. 23:1-21.

JOHNSON, S. E. 1917—Structure and development of the sense organs of the lateral canal system of selachians (*Mustelus canis* and *Squalis acanthias*). J. Comp. Neur. 28:1-75.

KLEEREKOPER, H. AND E. C. CHAGNON 1954—Hearing in fish with special reference to *Semotilus atromaculatus atromaculatus* (Mitchill). J. Fish Res. Bd. Can., 11:No. 2, 130-152.

LANDACRE, F. L. AND A. C. CONGER 1912—The origin of the lateral line primordia in *Lepisosteus osseus*. J. Comp. Neur. 23:575-617.

LEE, F. S. 1898—The functions of the ear and the lateral line in fishes. Amer. J. Physiol. 1:128-144.

LEKANDER, B. 1949—The sensory line system and the canal bones in the head of some Ostariophysi. Acta Zool., Stockh. 30:1-132.

MANIGK, W. 1933—Der Trigemino-Facialis-Komplex und die Innervation der Kopfseitenorgane der Elritze (Phoxinus laevis). Z. Morph. Ökol. Tiere 28:65-106.

MILLER, R. R. 1948—The cyprinodont fishes of the Death Valley system of eastern California and southwestern Nevada. Misc. Publ. No. 68, Mus. Zool., Univ. of Mich.: 1-155.

NORRIS, H. W. 1932—The laterosensory system of *Torpedo marmorata*, innervation, and morphology. J. Comp. Neur. 56:169-178.

PARKER, G. H. AND A. P. VANHEUSEN 1918—The reception of mechanical stimuli by the skin, lateral-line organs and ears in fishes; especially *Amiurus*. Amer. J. Physiol. 44:463-489.

PEHRSON, T. 1944—The development of latero-sensory canal bones in the skull of *Esox lucius*. Acta Zool., Stockh. 25:135-158.

——— 1945—The pit organ lines in *Gymnarchus niloticus*. Ibid. 26:1-8.

——— 1949—The ontogeny of the lateral line system in the head of dipnoans. Ibid. 30:153-182.

POLLARD, H. B. 1892—The lateral line system in siluroids. Zool. Jahrb. Ab. Anat. u. Ontogenie, 5:525-551.

SAGEMEHL, M. 1891—Beiträge Zur Vergleichenden Anatomie Der Fische. IV Das Cranium Der Cyprinoiden. Morph. Jahrb. 17:491-595.

SÄVE-SÖDERBERGH, G. 1941—Notes on the dermal bones of the head in *Osteolepis macrolepidotus* Ag. and interpretation of lateral line system in certain primitive vertebrates. Zool. Bidrag. Uppsala, 20:523-542.

SCHULZE, F. E. 1870—Ueber die Sinnesorgane der Seitenlinie bei Fischen und Amphibien. Rostock, Archiv. f. Mikr. Anat. 6:62-88.

SMITH, G. M. 1930—A mechanism of intake and expulsion of colored fluids by the lateral line canals as seen experimentally in the goldfish (Carassius auratus). Biol. Bull. 58:313-321.

——— 1933—The mechanism of intake and outflow of fluids in the lateral line canals of fishes. Anat. Rec. 56:365-372.

SOLGER, B. 1880—Neue Untersuchungen zur Anatomie der Seitenorgane der Fische. I Die Seitenorgane von Chimaera. Arch. Mikr. Anat. 17:95-113.

STENSIÖ, E. A. 1947—The sensory lines and dermal bones of the cheek in fishes and amphibians. K. Svenska Vet. Akad. Handl. (ser. 3) 24:3-195.

TCHERNAVIN, V. V. 1946—On the Lateral Line System of Some Cyprinodonts (Order Microcyprini). Ann. Mag. Nat. Hist. ser. 11, 13:429-432.

TRETIAKOV, D. K. 1941—Seismosensory system of Scombricidae. C. R. (Doklady) Acad. des sci. U.R.S.S., 30(3):272-276.

——— 1944—Outlines of the phylogeny of fishes. Ibid. 43:1-176.

——— 1948—Morphology of *Tinca tinca*. Trud Inst. Zool. Akad. Nauk Ukr. R.S.R. 1:21-28. (In Ukrainian. Not read by author.)

Factors Influencing Size and Composition of Populations of Rana clamitans[1]

Bernard Martof
University of Georgia, Athens

Recent strides in genetics and evolution have indicated that the development of genetic variation within a population is closely related to the structure of that population. Such factors as size of breeding populations, periodic fluctuations in the size of the population, sex ratio, size of activity range, and differential survival of progeny, determine to a great extent the relative importance of the roles played by mutation, natural selection and random fluctuations of gene frequency in determining the genetic composition of a species (Wright, 1940; Dobzhansky, 1941). Accordingly it is desirable to secure information on the population structure of several kinds of organisms. With the development of statistical methods in recent years much impetus has been given to the study of populations. As a result, many studies have been made of natural populations of animals. These chiefly include animals of direct economic importance, such as plankton and fishes, insects, birds, and mammals. Nevertheless there is still a great lack of adequate comparative data for the above mentioned groups. Some work has been done with populations of reptiles but relatively little study has been made of amphibian populations. This has suggested the present study of the population structure of the green frog, *Rana clamitans*. A description of study areas and general methods is contained in earlier publications (Martof 1953 a, b, 1956).

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In order to understand more thoroughly the changes in the size and composition of green frog populations, it is necessary to discuss some major events in the life history which influence the populations of this amphibian. Accordingly a discussion of hibernation, reproduction and mortality follows.

Hibernation

Green frogs emerged from hibernation in the last week of March in both 1948 and 1949, at which time the mean daily temperature had risen above 40° F, or, more importantly, the maximum temperature was above 60° F for three or four days. However, it was not until early April that they were found in sizable numbers. Rainfall, as well as temperature, played an important role in causing the frogs to emerge from hibernation. It was difficult to evaluate the significance of each, especially from field observations, because rainfall usually accompanied high temperatures. Since water has a high specific

[1] This paper is extracted from a dissertation submitted at the University of Michigan. It was expanded and prepared for publication while the author was on the staff of the University of Georgia.

heat, warm rains were very effective in releasing frogs from their hibernacula. This close association of temperature and rainfall in stimulating amphibian activity in the spring was earlier noted by Wright (1914), Cummins (1920), and Blanchard (1930). Inasmuch as green frogs, as well as other amphibians, hibernate under variable conditions, it is probable that the period of warm weather necessary to arouse some of them would be longer than for others. Accordingly, emergence from hibernation would be expected to be a somewhat gradual process. This is true for the green frog but not for most other salientians, which breed shortly after coming from hibernation. Perhaps a hormonal influence is responsible for their early mass appearance.

Green frogs started to go into hibernation in the last two weeks of October. By mid November none was found in the study areas. At this time the mean daily temperature registered about 40° F and the maximum temperature had not gone above 60° F for several consecutive days. The last green frog taken in 1948 was on November 13, the last one in 1949 on October 29. Thus the frogs had an activity period which extended over approximately 220 days, with no signs of aestivation. There are, however, reports taken in the vicinity of Chicago (Pope, 1947) of green frogs being active during mild weather in the winter months, especially near springs.

No special attempt was made to locate frogs in hibernation, although early in the spring they were observed at Loch Alpine hibernating in the mud or debris on the stream bottom in water about a meter deep. Judging from the numerous records of frogs which were taken in the same sites before and after the winter season, one may conclude that an individual usually hibernates in its home range (Martof, 1953b).

In Tasmania, Blanchard (1929) observed that prior to hibernation many more sexually mature females of *Crinia tasmaniensis* were found than males, and that immature individuals were scarce. He reasoned that a female had to keep actively feeding in order to produce the next season's eggs as well as to provide sufficient reserves for hibernation. Since he did not know the sex ratio of the whole population, it is difficult to evaluate his conclusion.

My observations did not indicate a similarly prolonged feeding period for female green frogs. In contrast to Blanchard's findings, the smaller frogs preceded the adults out of hibernation and were also the last to enter it. Thus it appears that the smaller individuals remain active at lower temperatures. A plausible explanation seems to be provided by the surface-volume relationship. The larger amount of surface area per unit of volume of the smaller frogs permits them to warm faster than the large ones and consequently they can become active sooner in the spring. In late fall the smaller frogs responded more rapidly to rises in temperature than the larger ones, becoming active with a shorter warm period per day. Thus their activity was more closely correlated with the daily fluctuations in temperature than with the seasonal fall in temperature, as was true for large frogs.

Several other factors undoubtedly operated to control the time of emergence from, or entrance into, hibernation. A few are mentioned below. (1) The rate of internal conditioning for hibernation or for renewal of activity (Holzapfel, 1937) may vary with size or stage of sexual maturity. (2) Small

frogs were found to be active mostly in the daytime, in contrast to the nocturnal activity of the large ones. (3) Availability of different sized individuals for capture must also be considered. In the fall, subadults constituted about 80 to 90 percent of the total population; accordingly, their chances of capture were greater. Perhaps individual differences in toleration only are shown in the data. In summary, ecological factors operate to determine the size and composition of the population throughout the season of activity.

REPRODUCTION

The breeding season of the green frog in the areas studied was not an "irruptive" spring phenomenon as is typical for most amphibians. Instead it was late and prolonged, being much longer than the breeding seasons of the other frogs of southern Michigan.

At the onset of the breeding season, about the first week of May, adult males were absent from their usual places along the banks of the streams. They were found in the ponds and lakes or else in the quiet waters of larger pools along the stream, spending much time calling. Within the next two to four weeks most males left the temporary calling sites along the stream and formed large congresses in the more spacious ponds and lakes. Here most males stayed until about the middle of August.

Females did not spend so much time at the breeding places. They stayed in the nonbreeding habitat until they were ready to spawn, when they made their way to the ponds occupied by the males. As censuses of the areas could not be complete and the periods of collection were usually a week apart, it was difficult to establish the length of time females were in the breeding ponds and the rate of travel of frogs going to and from the areas. However, the data suggest that females were in the spawning places from a few to possibly 34 days. Judging from the small numbers of records of females taken at the breeding sites, it is doubtful if the average female spent more than a week away from the nonbreeding habitat while carrying on reproductive activities.

Reproduction took place in the quiet, plant-grown waters of ponds and lakes. Only twelve egg clusters were found in the two years of study (two in 1948, ten in 1949). The eggs were deposited in irregular, flat clusters on the surface of the water amid emergent and floating vegetation. In addition, the egg clusters were difficult to find because of their rapid development; but three to five days were required for hatching. Each cluster had an area of 100 to 130 square inches, the greatest diameter being about 12 inches. Although the number of eggs in observed clusters was not ascertained, three gravid females were dissected and their ovaries removed and weighed. From counts of the eggs in samples of the ovaries, the total number of eggs in the three specimens was estimated as 3,800, 4,100, and 4,300. These observations are in agreement with those of Pope (1947) who gave 3,500 to 5,000 as the complement of ova in clusters of northern green frogs. He also reported that the smaller southern females laid as few as 1,000 eggs. A detailed description of the eggs has been published by Livezey and Wright (1947).

All gravid individuals examined contained the partly developed ova to be laid the next year in addition to the mature eggs of the current season. These

developing eggs were about one-third the diameter of the mature ones and devoid of pigment. In number they approximated those already mature. Because each of seven females collected June 6, 1950 had two sets of eggs, it seems probable that one year is the normal period required for the maturation of eggs.

The depth of water where egg clusters were found ranged from six to twenty inches, with an average of ten. It is of interest that more clusters were found in the smaller and more densely vegetated western pond at Hogback than in the deeper, more exposed middle pond. The earliest cluster was found on May 31, 1949, the latest on July 12, 1949, and the most (eight) on July 8, 1949. All clusters observed were at Hogback. Undoubtedly earlier and later layings do occur as shown by the fact that a female, taken on August 9, 1949 at the Hogback area, released some eggs upon capture. It is also possible that all gravid females do not lay each year. Gravid frogs kept in the laboratory resorbed their eggs.

Two factors seemed to determine when a frog went to the breeding area. (1) It had to be in a state of internal readiness and (2) weather conditions had to be favorable. These are discussed below.

Before a frog participated in reproductive activity, maturation of its gametes and concomitant hormonal stimulation evoking breeding behavior had to occur. Most males were stimulated to sexual activity early in the season while females apparently became reproductively active at different times throughout the season, as evidenced by their sporadic movements to the spawning area. However, no gross difference was seen in the state of development of the eggs of seven females dissected on June 6, 1950. In males, it was repeatedly observed that subadults became mature in July and August, as judged by a change in the relative diameter of their tympana, appearance of yellow throat pigment, and movement to the breeding sites where they actively called. As there was no external evidence indicating when a female became sexually mature or the stage of development of its gametes, and since only a few females were taken in the breeding areas, it was difficult to judge them. Because a year is required for development of eggs, no small gravid females were identified; consequently, they did not go to the breeding ponds in the same season in which sexual maturity was attained. Therefore, the time of attainment of sexual maturity of females and the rate of maturation of eggs must be more clearly understood before an explanation of the prolonged reproductive season can be provided.

In addition to the state of internal readiness, weather conditions determined when green frogs went to the breeding areas and consequently the intensity of reproductive activity in the population. It was surprising that so aquatic a species was strongly affected by air temperature and precipitation, particularly the latter. Early in the season, temperature was the main factor (fig. 1). In 1949 the warm weather and moderate rainfall of the first half of May did not induce the frogs to begin breeding activity, but did sufficiently warm the water in the ponds so that with the onset of warm weather later in the month the frog choruses were very active and the first egg cluster of the season was found. In the meantime there had been no rain. Later in the

year when temperatures were well above the threshold, precipitation appeared to be the controlling factor. It should be noted that the weather record is complete but only weekly samples of the population were taken; however, generally the size of all collections correlates directly with rainfall.

Weather conditions also played an important role in determining the time spent at the breeding areas. Movements from these places were usually made in dry weather. In periods of no rainfall reproductive activity, including calling, came to a standstill. Some frogs foraged on the periphery of the ponds and others returned to the brooks where they may have been transient, moving to more permanent breeding sites. In dry weather, males were captured en route as they moved from the ponds. The records of two females taken at Hogback also clearly exemplify this relationship to weather. They were first captured on June 27, 1949 along the edge of a breeding pond. Two days later one was taken, still gravid, along the brook 105 meters away. The following week both were taken at the pond and had laid their eggs. These movements were directly correlated with the weather conditions. Precipitation promoted movement to the breeding area and eventually the deposition of eggs as shown by the fact that all egg clusters, except the one found early in the season (May 31) were first observed immediately after rains. Lack of rainfall, on the other hand, caused the withdrawal of frogs from the spawning site (fig. 1). During dry weather there were many nights in which heavy

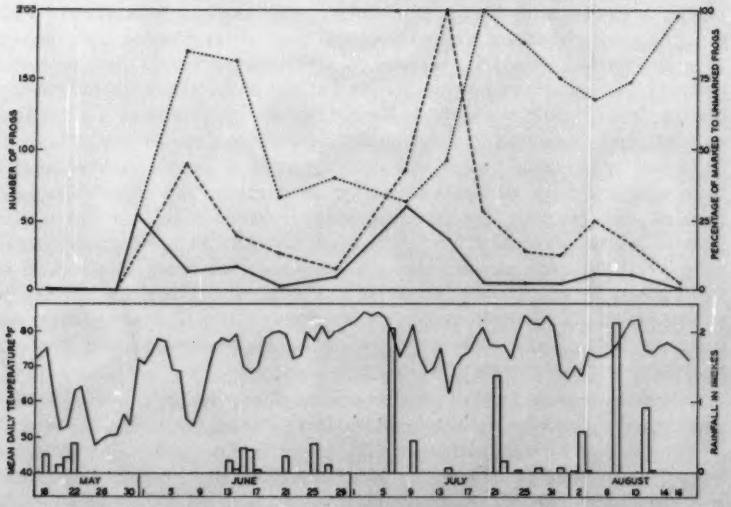


Fig. 1.—Correlation of breeding activity with temperature and rainfall. The upper part of figure shows the actual number of males captured (——), the estimate of the total population made by the proportional method (- - - -), and the percentage of marked to unmarked males caught (. . . .) in the breeding ponds at Hogback from May 18 to August 16, 1949. The lower part of the figure gives the mean daily temperatures and daily rainfall (vertical bars) at the Willow Run Airport, five miles east of the study area.

dew provided wet conditions near the ground. However, this stimulus was not enough to promote reproductive activity, but was adequate to permit green frogs to return overland to more permanent habitats.

In summary, the length of the breeding season is directly dependent upon the weather. More favorable weather conditions (warm and/or rainy) would shorten the season whereas adverse circumstances (cold and/or dry) would cause the season to be prolonged by causing temporary cessation of activity.

The weather data in fig. 1 are from the Willow Run Airport, located about five miles east of the Hogback study area. It is realized that they do not portray in detail the weather conditions in the breeding site, but they do show the major trends.

The fundamental importance of isolation in the formation and maintenance of species has been strongly emphasized by geneticists (Dobzhansky, 1941). Moore (1949) found that the green frog is clearly isolated developmentally from other sympatric members of the genus. The eggs of the green frog when fertilized by other species did not cleave at all and the reciprocal developed to the blastula stage only. In addition to developmental incompatability, green frogs are isolated by other mechanisms that function to conserve the gametes of the species. My data show that the green frog bred during a season distinct from that of *R. sylvatica, R. pipiens,* and *R. palustris.* In spite of the overlapping seasons of *R. clamitans* (May 15 to August 15) and *R. catesbeiana* (May 20 to July 20), crossing was hindered by at least two features. Their spawning habitats differed considerably, *R. clamitans* breeding in the ponds at Hogback and on the periphery of the lakes at Loch Alpine, whereas *R. catesbeiana* mated only in the deeper waters of the lakes. Furthermore the voices of these species are very different and serve to segregate the species when calling in the same body of water. Thus the green frog is clearly isolated from related species by a combination of factors: hybrid inviability, differences in time of reproduction, habitat differences during the breeding season, and probably by its characteristic voice.

MORTALITY

The incidence of mortality within various size groups was hard to evaluate because most of it resulted from predation, particularly on the smaller frogs, thus generally removing the evidence from view. Seven of the fourteen dead animals found were obviously killed by predators, snakes being chiefly responsible, one frog being obtained by forced regurgitation from *Natrix sipedon* and three from *Thamnophis sirtalis.* Another green frog was found partly swallowed by *Rana catesbeiana.* Parts of two freshly killed and partly eaten frogs were observed scattered about on the banks, probably the work of crows. Of the seven other dead frogs, one had small red spots (about three mm in diameter) over the ventral surface of the abdomen, and another had a severe wound, with torn flesh and skin on the dorsal surface of the thigh, accompanied by an acute infection of "red leg" bacillus (*Bacillus hydrophillus fuscus*). All others showed no signs of injury, suggesting that diseases probably are important controls in populations of frogs.

A multitude of enemies harass green frogs, so that only a small proportion

of the eggs laid develop into sexually mature animals. Accordingly the literature abounds with references to frog predation, but in this report only some of those that pertain to predators observed on the study area are included.

The eggs of green frogs are subjected to many predators among which are the snapping turtle (*Chelydra serpentina*) and the painted turtle (*Chrysemys picta*). Both ate clusters of frog eggs in the laboratory and probably also consume them in nature.

Many aquatic insects such as larvae of diving beetles (Dytiscidae), water beetles (Hydrophylidae), whirligig beetles (Gyrinidae), adults and nymphs of giant water bugs (Belostomidae), water scorpions (Nepidae), and backswimmers (Notonectidae), naiads of dragon flies (Aeschnidae and Libellulidae), and many others are predacious and destroy tadpoles, especially small or recently hatched ones, in great numbers (Lutz, 1935; Essig, 1942).

In addition, carnivorous fishes, especially bass and catfish, prey upon tadpoles and small frogs (Breckenridge, 1944). Furthermore, green frogs are actually their own enemies; the large ones will feed on smaller ones of their own or other species. However, the larger *R. catesbeiana* is a more formidable predator. Tadpole behavior for most species is not clearly understood, but "some species of *Rana* are known to be cannibalistic" (Noble, 1931).

Reptiles are perhaps the greatest enemies of frogs. That snakes of the genera *Natrix* and *Thamnophis* devour many of the smaller species of frogs is well known. I found that even the large green frogs and bullfrogs with snout-vent measurement as long as 113 and 122 mm were eaten by these snakes. Other reptilian enemies are the aquatic turtles. According to Pope (1946) the snapping turtle is especially destructive of tadpoles and frogs. Blanding's turtle (*Emys blandingi*) is also reported to eat tadpoles and frogs (Cahn, 1937).

Next to snakes, birds are probably the chief predators on frogs. The black duck and mallard feed avidly on tadpoles and frogs and can easily deplete the frog populations of small ponds. The black crowned night heron, great blue heron, green heron, American bittern, and king rail stalk the shallows in search of frogs and tadpoles. A heavy toll of frogs is also taken by the marsh hawk, the red-shouldered hawk, and the crow.

Dearborn (1932) reported that a few mammals eat frogs, the latter comprising .33 percent of the food of the opossum, .01 percent for the raccoon, and 5.75 percent for the mink in summer and 8.55 percent in winter. These data are not representative for all seasons because they are taken primarily from animals caught for fur in the winter months.

Finally man, by his collecting of frogs for food and study, drainage and pollution of streams, use of the automobile, and other ways, makes life precarious for individual green frogs.

At Loch Alpine the common garter snake was the most abundant predator, being seen most days on which green frogs were captured. As many as ten were observed in one day, the average being between two and three. During most of the summer it was common to see a heron or two each day, the great blue heron being about twice as abundant as the green heron.

At Hogback the common garter snake was also the most often seen predator and was encountered with greater frequency than at Loch Alpine; as many as

fourteen were seen in one day, the average being about three. However, not a single one was found to contain any green frogs, whereas three frogs were found in garter snakes at Loch Alpine. The lower density of garter snakes, and the presence of numerous frogs of related species, especially leopard frogs, reduced the predation on green frogs. On the other hand, the population of avian predators was greater and more varied at Hogback. An average of about four of them were observed in the area each day through most of the season, the most regular being the green heron, American bittern, great blue heron, black duck, and crow.

Assuming other things to be equal and in view of the fact that the major predators of green frogs, reptiles and birds, are comparatively large, surely a large frog would appease a predator's appetite longer than would a small frog; therefore, more small ones would be eaten. Another consideration is the premium on size in frog communities; as the large ones can and do swallow smaller ones, there seems to be no doubt that vulnerability to predation varies with size.

In addition to predation, there are many other factors that contribute to mortality of green frogs. Among the more important are deformities, injuries, parasites, diseases, and adverse weather conditions. Some data were obtained on these and are given here.

Deformities were frequently encountered, especially among newly transformed frogs. The hind leg was particularly affected, 18 individuals being observed with one hind foot of abnormal shape or proportions—practically useless as a swimming organ, eight lacked a hind foot, and three others had both shank and foot missing. On the other hand, only one frog lacking a front foot (actually the entire leg) was collected. This individual was a female 79 mm long, whereas the largest frog with a deformed or absent hind foot was but 42 mm. The detrimental effect on survival of hind foot anomalies is unequivocally indicated. Omission of toes was noted, usually affecting only one of the hind feet: four frogs had one toe missing, two had two toes missing, and one had lost three toes.

In addition to possible genetic factors, the greater vulnerability of the hind feet, especially in the tadpole stage, was perhaps responsible for the greater incidence of deformities on this part of the animal. Since the hind legs developed weeks before the front ones, which appeared shortly before metamorphosis, crayfishes, predatory water beetles and bugs, fishes, and other animals undoubtedly attacked these dangling appendages.

It is interesting to note the frequency with which external deformities were encountered among newly transformed green frogs. Of the 428 taken at Hogback in 1949, 23 had deformed parts. This percentage may be slightly above the actual incidence of such abnormalities because the more agile, normal animals moved out from the breeding area more promptly. Because of the marked absence of deformities among larger frogs, these defective, newly transformed frogs are thought to be highly vulnerable to predators.

Two females (42 and 76 mm) possessed no clues that they ever had a second eye, for a continuous layer of skin covered the site. A third female of 88 mm had no vision in its right eye, the pupil remaining wide open

with no adjustments for changes in the intensity of light. Absence of a tympanum was noted but once, in an 85 mm male.

A curious deformity was observed in a Loch Alpine frog, probably in its second year after transformation. Its lower left jaw curved downward and slightly outward, making its mouth permanently open. This individual was observed several times from June 18 to October 11, 1949, in which period it grew from 63 to 71 mm. Since this was only about 65 percent of the average growth that could be expected for a frog of this size (Martof, 1956), it was concluded that this deformed individual was probably unable to capture food well. Normally a frog's mouth must be tightly closed to permit breathing but it was anatomically impossible for the animal to close its mouth. It appeared to swallow air by laborious breathing movements. With each attempt, the tongue only partly occluded the opening created by the malformed jaw.

Injuries frequently occurred to transformed frogs. the fourth toe of the hind foot being the most frequently damaged part of the body. In general, the incidence of injury was high for all the hind digits and correlated directly with their lengths, the longer ones being more vulnerable. About 78 percent of the 46 toe injuries observed resulted in the loss of the distal part of the digit. Twenty-one torn webs of the hind feet were noted, all but three involving the longest (fourth) toe. Injuries were observed among frogs of all sizes; however, their incidence was 2.6 times greater at Loch Alpine than at Hogback. The major contributing factors seemed to be the predatory activities of the rock bass (*Amblopites rupestris*), the stony nature of the stream, and the steepness of the banks; these were absent from the Hogback area.

Six living frogs were observed with torn skin and flesh on various parts of the body, and eighteen others had conspicuous scars. Sixteen animals were noted with broken bones, all in the hind appendages. The phalanges were the most frequently broken bones of the body, those of the fourth toe being most vulnerable. Two frogs with broken tibio-fibulas and three with fractured femurs were also observed. Fractured parts were easily recognized after mending because of large knobby outgrowths of bone.

Four individuals with ruptured tympana were captured. Each had a suppurative and inflamed sore on the tympanum, which was constantly aggravated by breathing, because of air leakage via the Eustachian tube. Two others had similar sores on the abdomen through which parts of the viscera extruded. None was recaptured.

Parasitic representatives of many phyla have been observed abundantly in and on amphibians, particularly the ranids (Noble, 1931). Walton (1947), in an annotated catalog of the parasites of the Ranidae, listed for the green frog 13 species of Nematoda, 36 of Trematoda (12 in tadpoles), three of Cestoda, one of Copepoda (on tadpoles), one of Acarina, three of Diptera, and 32 of Protozoa (15 in or on tadpoles).

Leeches, important ectoparasites of breeding male green frogs, should be added to the above list. Approximately 80 percent of the males in the breeding ponds were infested, the webs of the hind feet being a favorite location. Along the streams leeches were found on green frogs only twice, probably because there the frogs were more active and occupied places less favorable

for leeches. In addition to feeding on tadpoles and frogs, leeches are reported by Maestri (1931) to be responsible for the destruction of frog eggs.

The incidence of the bacterial infection, "red leg," was very low; only three afflicted frogs of 60-70 mm were observed. For one animal the infection may have been secondary, as it was injured and moribund.

Before we can adequately understand the role of parasitism, faunal studies of the parasites of individual frogs must be made. The vulnerability of different sized animals to parasites, the intensity of infestations and of the damage inflicted upon individuals, the distribution and density of the parasites in the population, and the influence of the parasites upon population size, either as they affect the frogs directly or indirectly through increasing their vulnerability to predation, must be known before an evaluation of the role of parasites in the ecology of frogs can be made.

During summer droughts the tadpole population may suffer from excessive crowding and also from the concentration of their predators into a smaller area (Lynn and Edelman, 1936). If the drought is severe enough, as was observed in 1948 at Hogback, the breeding sites may dry up completely, killing thousands of tadpoles (Martof, 1956). Undoubtedly other adverse physical conditions, such as those of severe winter may directly cause heavy mortality.

SIZE OF POPULATION

METAMORPHOSING FROGS

At the start of the season of metamorphosis, early in August, 1949, the population of newly transformed frogs at Hogback was so dense that the usual method of censusing had to be abandoned. Before, there were no subadults in the ponds, only adults being taken, consequently all small individuals had to be recently transformed ones. Innumerable tadpoles were observed, but only those transforming individuals with front legs available for marking were counted. As the study area was already conveniently laid out into ten-meter squares with markers at the corners of each square, a quadrat study was undertaken.

The quadrat sampler, a wooden frame one meter square and eight inches high, was provided with a four-inch metal strip that projected two inches beyond the bottom of the wooden sides, making the sampler ten inches in height. This height proved adequate to prevent frogs from jumping out. The metal strip clearly defined the square meter to be sampled and also reduced the width of the bottom edge, thus decreasing the chances of mortality resulting from use of the sampler. A wooden bar across the middle of the sampler and handles on the sides facilitated lifting, carrying, and throwing.

Random samples were taken each week from August 9 to October 5, the season when the population of newly transformed frogs was large. Two selections of marked cards from a box were necessary to determine the location of each quadrat. The first indicated the ten-meter square to be sampled and the second the location of the quadrat within that ten-meter square. Upon being selected, all quadrats were located on a map of the area to determine whether they were in the subdivision of the area being studied. If a quadrat happened to be located upon the boundary line of a subdivision, it was included

if more than half of its area was in the subdivision being sampled; otherwise it was discarded. Usually all samples of each series were taken in the field on the same day; if not, then the sampling was completed on the following day.

Samples were located quickly and accurately by pacing the appropriate number of meters from the randomly selected markers. When within two or three meters of the predetermined place, I threw the sampler so that it would fall as perpendicularly as possible on the precise area to be sampled. This prevented the vegetation, which might entrap and possibly injure frogs, from being held down by the sampler. In addition, bouncing was prevented, and the metal strip was able to penetrate into the substrate, thus preventing frogs from escaping under the bottom edge. As those frogs closer than a meter usually moved to escape when approached, the sampler was thrown far enough ahead to fall on an area where the frogs were undistributed. Thus the samples were not influenced by possible driving of the frogs. In the vicinity of trees it was sometimes impossible to place all of the sampler on the actual area as determined by the drawing, but at all times care was exercised to get the sampler as close as possible to the selected spot. Fortunately the terrain was generally level enough to permit it to rest squarely on the ground.

Usually, enclosed frogs were easily captured by hand in the corners and along the sides of the sampler. During all the sampling only a few frogs succeeded in jumping out and even these were overtaken and captured. The sampler was effective in retaining adults as well as newly transformed frogs. In fact, it was frequently used to capture adults in places where capture was normally difficult, as in dense vegetation and deep water. In the ponds the sampler worked as well as on land, but for use in deep water, another wooden frame was attached to the top giving an over-all height of twenty-four inches. In water up to about a foot in depth the sampler was searched by hand, but in deeper water a net was used.

In August, when the transformation seasons for *R. pipiens, R. sylvatica,* and *R. palustris* were over, newly transformed individuals of *R. clamitans* became the most abundant frogs on the area. Because of the more aquatic habits of the green frogs, they were restricted to the breeding ponds and here their distribution was limited by the depth of the water. Some of these newly metamorphosed frogs later dispersed outward to the stream, but their numbers did not become so great that the usual see-capture method could not be used.

In order to get a reliable estimate of the population of newly transformed frogs in the ponds and at the same time a picture of their distribution, the study area was arranged into the following subdivisions: (1) A part, in which the water was deeper than eight inches. Only a few green frogs were captured during the entire season and none while sampling. Myriads of large tadpoles were taken, but apparently transformation occurs in shallower water. (2) A shallow-water region that extended from the eight-inch water contour line to the shoreline (water's edge) and included 6,090 square meters. It was in this section that all captures were made with the sampler. (3) The land plot, which started at the shoreline and included the remainder of the study area. Exclusive of the brook and its immediate vicinity, this subdivision

apparently contained no green frogs, though regularly surveyed to study the *R. pipiens* population.

The estimate of the number of newly transformed frogs in the breeding area in each sampling period was obtained by multiplying the mean number of frogs per sample for that period by the total number of possible samples in the shallow-water subdivision (6,090). Because the chances of a frog's being unnoticed or escaping capture were far greater than the chances that an individual would move into the sampler once it had been thrown, these estimates are regarded as conservative.

To learn how accurate each estimate was, confidence limits were applied. Since about 45 samples were taken during each period, large sampling technique was used, and in view of the skewed distribution of the numbers of frogs taken in the samples, skewness was considered in order to produce a more realistic picture of the population. It was repeatedly observed that the frogs were not randomly distributed in the shallow-water zone, but appeared to be more heavily concentrated in the *Eleocharis* patches, which were mostly in four to six inches of water. Because a large number of random samples was taken, the skewness of the mean number of frogs taken per sample was interpreted to be the skewness of the population estimate divided by the square root of the number of samples taken.

$$a_3 \text{ of the mean} = \frac{\mu_3}{\delta^3} / \sqrt{N}$$

where a_3 = skewness, μ_3 = third moment of the variable about the sample mean, δ = standard deviation of the sample, N = number of samples taken. The above formula is from Kenney (1939).

All values of skewness were positive, indicating that the range of estimation was greater above the mean than below. Values of "t", which is the deviation from the mean divided by the standard deviation, were obtained from Salvosa (1935) for the one percent level of significance (99 percent probability) and for the appropriate skewness. Then fiducial limits of the mean number of frogs per sample were estimated by the formula

$$M + \frac{t_L \delta}{\sqrt{N}} \leqslant \text{mean} \leqslant M + \frac{t_u \delta}{\sqrt{N}}$$

where M is the mean number of frogs per sample, t_L is determined so that 0.5 percent of the distribution is excluded from the lower end and t_u so that 0.5 percent is excluded from the upper end. (Rider, 1939). By multiplying the range of the mean of the samples by the ratio of the total area to that of an individual sample, conservative limits are obtained for the range of the estimated population size.

Two weeks after the first appearance of newly transformed green frogs, the peak population occurred. This sudden rise in numbers is in contrast with the steady decline that followed, perhaps indicating the close relationship of temperature and green frog development. That is, when the daily temperatures were high, development was rapid and the number of newly transformed frogs was high, and as the seasonal fall in temperature occurred the rate of develop-

TABLE 1.—Weekly estimates, derived from quadrat study, of the population of newly transformed green frogs in the breeding ponds at Hogback in 1949.

Date of sampling	No. of samples	Mean no. frogs/sample	Estimated mean pop.	Upper limit	Lower limit
Aug. 9	88	.045	300	680	5
Aug. 18-19	50	1.280	7,800	11,880	4,410
Aug. 24-25	40	1.750	10,660	16,940	5,370
Sept. 2-3	40	1.117	7,160	10,980	3,890
Sept. 8	37	.568	3,460	6,290	1,120
Sept. 15	35	.543	3,310	7,250	520
Sept. 21	35	.268	1,740	4,250	120
Sept. 28	35	.143	870	2,200	5
Oct. 5	25	.040	240	1,070	5
Total	....	.....	35,540	61,540	15,495

ment, hence transformation, was retarded. A direct correlation is indicated between the number of adult males in the breeding ponds and the number of transformed frogs found later in the season. The initial peak of metamorphosis, as shown by the large number of newly transformed frogs on August 25, is followed by a drop and a leveling off in numbers from about September 8 to 15 (table 1).

These changes correspond to the curve of the captures of males in the breeding ponds; a peak of abundance on May 31 was followed by a plateau from about June 7 to 14 (fig. 1). Assuming that the number of males in the breeding ponds is representative of the reproductive activity—the number of egg clusters laid—at that time, and that mortality is approximately the same for all eggs, regardless of the date when laid, then it seems logical to conclude that practically all eggs laid prior to about June 25 developed into frogs in that same season. Because of the small number of captures made by quadrat study on October 5, this method was not used later in the season when the population was even smaller.

Of the 286 newly transformed frogs taken in the ponds at Hogback, only two were recaptured. This low rate of recovery (0.7 percent) indicates a very high rate of turnover of population, suggesting that, on the average, less than a week was spent in the ponds by a frog after it had transformed.

ALL FROGS

Some insight into the total number of frogs in the study areas was gained by capturing, marking, and releasing a part of the population and analyzing subsequent samples of the population for marked individuals (Petersen, 1896; Lincoln, 1930). The ratio of marked animals to the total number captured in a particular sample should be the same as the ratio of the total number of marked individuals to the total population, provided no reproduction, movement onto or from the area, or excessive mortality has occurred in the meantime. In this report, this procedure is referred to as the proportional method.

Emlen, Stokes, and Davis (1949) pointed out that the reliability of this method rests on the equivalence of the samples. Therefore, all must be random or else strictly equal with respect to the distribution of efforts to capture animals, and all individuals, regardless of size, sex, and whether they are marked or unmarked, must be equally susceptible to capture.

The study areas were sampled systematically; that is, they were surveyed once a week with no stipulation of time required. The objective was to procure as large a representative sample of the population as possible. Therefore, the more frogs seen, the greater the amount of time spent in any particular part of the area. This plan assured complete coverage of the area and a maximum sample of the population.

Because of such factors as breeding, dispersion, adverse weather conditions and high mortality a large turnover of frogs took place in the study areas. In addition, these factors influenced various frogs, i.e., males, females and subadults, differently.

Thus it is clear that the balance between marked and unmarked animals did not remain undisturbed from one sampling period to the next. In the green frog population, as in most natural populations, there was a steady stream of transient frogs, some of which replaced those that had died. In a dynamic population like that of the green frog, this turnover of individuals occurs at a rapid rate. Thus the applicability of the proportional method is questionable, and in this study it can at most be used to show only general trends.

Except during the fall season of transformation, the population at Loch

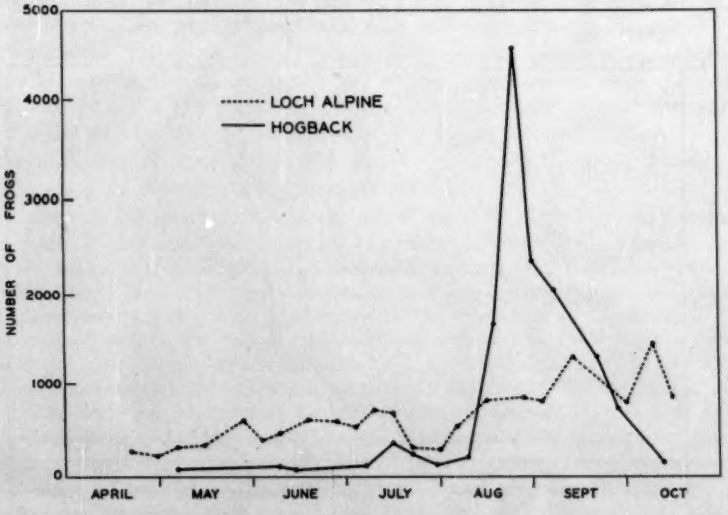


Fig. 2.—Estimates made by the proportional method of the number of frogs present in each study area at various times in 1949.

Alpine in 1949 was larger than that at Hogback. This is shown by the estimates (fig. 2) based on all captures made in each study area, and also by the fact that more captures were made there.

At Loch Alpine a population of about 500 frogs was estimated to be in the area from the last half of May to mid-July, when it decreased to about 300. This decrease was probably real because the proportion of unmarked to marked small frogs was definitely lower, indicating that most tadpoles from the previous season had already transformed. In August a large number of recently metamorphosed frogs moved onto the area, and the estimated number increased to about 1000. Because of the small number of frogs recovered at later dates the estimates are accordingly not very reliable.

The estimates made for the Hogback area show that a population of approximately 100 frogs were there through May, June, and the first week of July. A rise in mid-July to 200-300 frogs reflected the movement of outside frogs to the ponds for breeding activity (see estimates of population of breeding males at Hogback in fig. 1). In August about 4600 frogs were estimated in the area, most of them recently transformed individuals. Because all captures, including those made in the quadrat study were used, this estimate is obviously too low. A steady decrease in numbers, due primarily to dispersion, occurred throughout the remainder of the season.

In summary, general methods for determining the size of a population must be applied to green frogs with caution. There is a high rate of turnover of individuals from movement and mortality. In addition, the chance of capturing a frog in successive sampling periods was not very great—about one out of seven. For example, at Loch Alpine in 1949 about 75 percent of the adult frogs captured each week had been marked but the number that had been captured the previous week was discouragingly low, being only 10

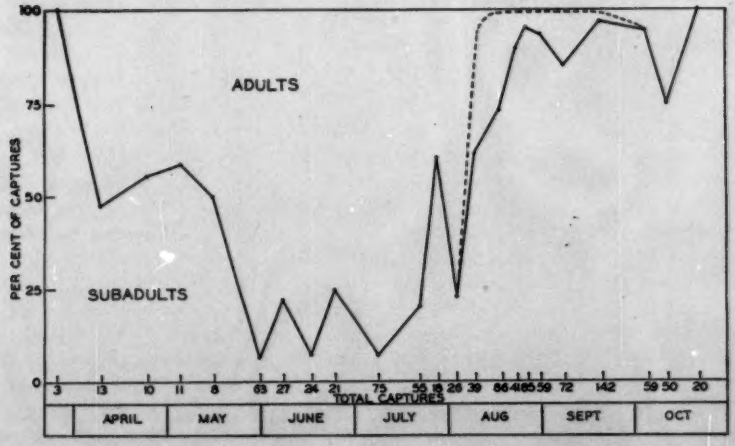


Fig. 3.—Seasonal variation in the relative abundance of subadults and adults in the Hogback area as determined by captures made in 1949. Quadrat data are indicated by a broken line.

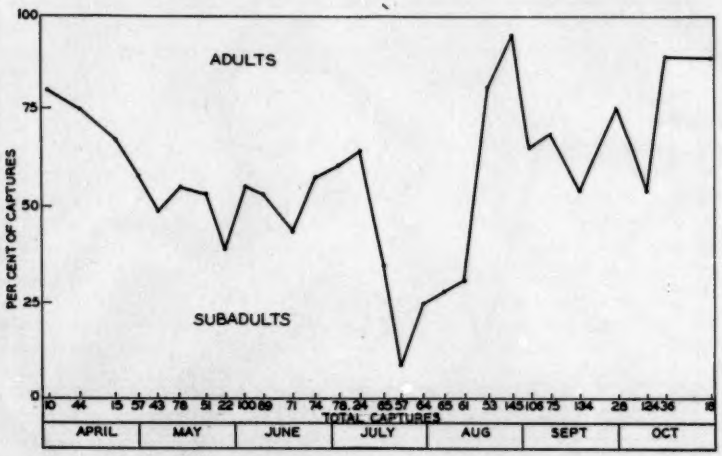


Fig. 4.—Seasonal variation in the relative abundance of subadults and adults in the Loch Alpine area as determined by captures made in 1949.

to 15 percent. For the subadults the rate of recovery of marked individuals varied considerably, but averaged 15 to 20 percent for each week, with about five percent of these from the previous period.

COMPOSITION OF THE POPULATION

In order to learn the relative abundance of different groups in the population throughout the season, figs. 3 and 4 were constructed to show the proportion of adults and subadults, and figs. 5 and 6 to demonstrate the ratio of males and females. A discussion of the factors involved in determining the abundance of these groups follows. Only the 1949 data are presented here; the 1948 records are in general agreement.

Early in the spring, subadults comprised about 80 percent of the captures at Loch Alpine and 100 percent at Hogback. Because of their small size, hence ability to respond quickly to rises in temperature, and their more diurnal habits, they were the predominant element in the green frog population. This high percentage was gradually decreased by the emergence of the adults from hibernation and by the greater dispersion and mortality of the subadults until in April at Hogback and in May at Loch Alpine the ratio of the sexually mature and immature frogs was approximately one to one.

The decline in numbers of subadults taken at Hogback in June and July showed, in part, the gap created by the absence of newly transformed individuals which was caused by drying of the ponds in 1948. Furthermore, the influx of breeding males into the ponds caused a relative decrease in the proportion of subadults present in the Hogback area. On the other hand, the exodus of sexually mature individuals from the nonbreeding areas at Loch Alpine produced a relative increase in the proportion of subadults.

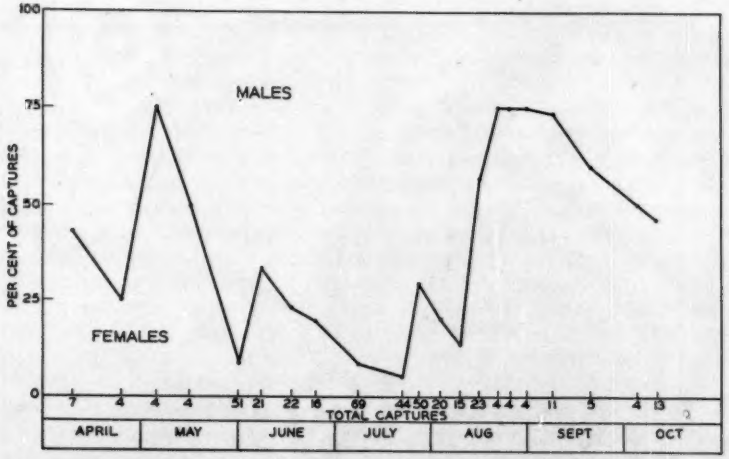


Fig. 5.—Seasonal variation in the relative abundance of adult males and females in the Hogback area as determined by captures made in 1949.

Replacements due to metamorphosis in June and early July were about equal to the losses created by mortality, growth, and dispersion.

During the latter half of July and the first or second week of August the population of subadults along the stream at Loch Alpine was at a minimum, being only ten per cent of the total population. The primary factor responsible was the complete lack of recruitment because the overwintering tadpoles had transformed earlier. This, in combination with continued mortality, movement, growth and subsequent maturation, caused a decrease in the number of subadults and a concomitant increase in adults. About 90 percent of the individuals that were observed to take on the secondary sexual characteristics of maturity did so in July and August. It is not definitely known whether these frogs were from the early or late metamorphic periods.

The increase in the number of subadults at Hogback in the last week of July is only relative. Note in fig. 5, which shows the ratio of males and females in the area, that there was a corresponding increase for the females. This effect was produced by an actual decrease in the number of males in the breeding ponds, creating a decline in the size of the total population (fig. 2).

About the middle of August the tadpoles hatched from eggs laid early in the season transformed and the percentage of subadults soared to more than 90 on both study areas. On August 27 the population of newly transformed frogs at Loch Alpine was too great to permit complete daytime coverage of the area. Therefore, as the actual proportion of the small to large frogs was not accurately indicated by the records of captures, a conservative estimate of 90 percent was made.

Meanwhile, at the Hogback ponds the increase in subadults was even more impressive, for after the middle of August they appeared to make up

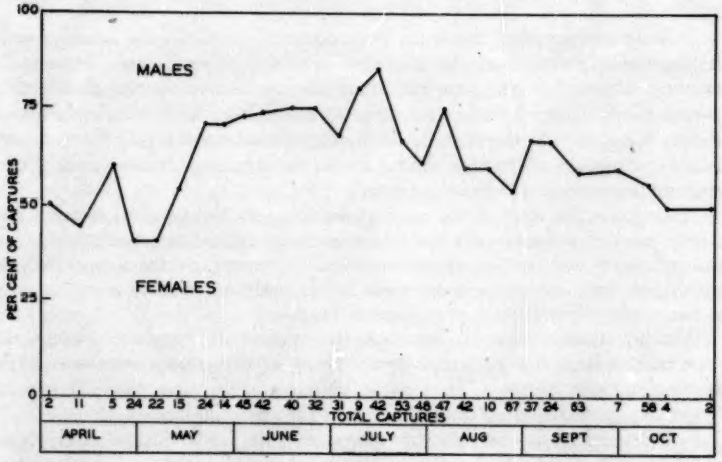


Fig. 6.—Seasonal variation in the relative abundance of adult males and females in the Loch Alpine area as determined by captures made in 1949.

about 95 percent of the population as shown by actual captures. A truer picture, obtained by using the quadrat-study data, showed them to comprise much more than 95 percent of the population throughout the latter half of August and most of September. At Loch Alpine the peak of abundance of subadults tapered off more rapidly (because of dispersion, mortality, and growth) to a level at which they constituted about 60-65 percent of the population throughout September and the first half of October.

Later in the season the subadults became relatively more available for capture than adults because of their ability to warm up faster and consequently to become active sooner and also because of their greater abundance. They then comprised about 85-90 percent of the captures.

As indicated above, the location of the breeding site with regard to the study area directly altered the composition of the population. Therefore, it was thought that a more representative picture of the actual ratio of males and females in nature might be had by considering records taken at times other than the reproductive period. A tally made of all males and females collected at Loch Alpine before the start of the breeding season (May 15) and after the close of the season (August 15) showed that 218 adult females and 171 adult males were taken. This is a ratio of 56 to 44. Because the available niches located near the breeding sites were usually already occupied by the earlier returned females and the recently matured individuals, which move in from subadult ranges, it is thought that most late returning males may have had to move to locations farther from the breeding areas in order to find adequate space. Therefore, if an area located farther from the breeding ponds was considered, perhaps the males would be found in greater abundance in the nonbreeding season than the females. Or if a larger area had been studied, a one to one ratio might have been obtained.

It is interesting that the sexes were captured in about the same ratio at the beginning and end of the season of activity. The changes imposed by breeding activity on the composition of the population in the nonbreeding habitat (Loch Alpine) and in the breeding area (Hogback) are clearly shown in figs. 5 and 6. At the start of the mating season there was a sharp decline in the percentage of males present in the nonbreeding habitat and a concomitant increase in the breeding ponds.

The prolonged stay of the male green frogs in the ponds and lakes had a very marked influence on the composition of the adult population. The ratio of males and females varied considerably throughout the season depending on whether collections were made at the breeding site or along streams in the nonbreeding habitat of the green frogs.

Females were seldom collected in the ponds at Hogback among the numerous males. Rather, the majority taken in that study area were established along the stream. They made up considerably less than 25 percent of the total population at Hogback during the spawning season.

In nonbreeding habitat, as represented by the Loch Alpine study area, males comprised only 25 percent of the population in June and July. Most of them were recently matured frogs, although a few were large transients, moving from the lake to another breeding site at a small pond west of the abandoned meander.

RATE OF RECOVERY OF MARKED FROGS

Some insight into the rate of population turnover for different sized frogs was obtained by first tallying the size at previous capture of all recaptured

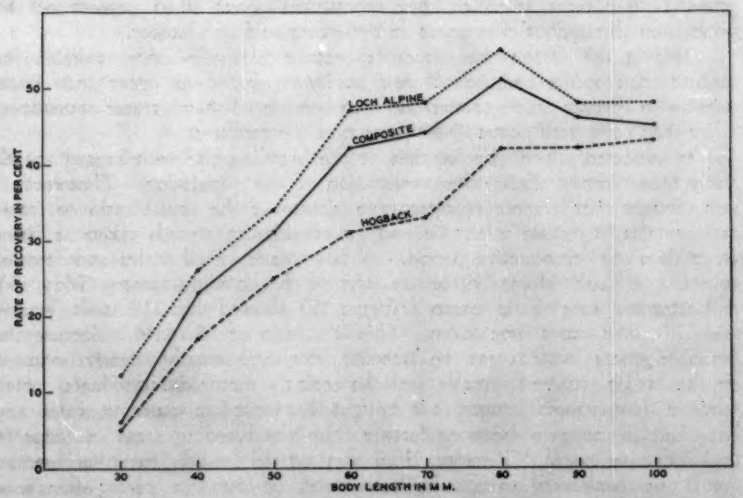


Fig. 7.—The rate of recovery of green frogs of different sizes in the study areas. The size is that at the time of previous capture.

frogs, and then calculating and plotting the ratio of recaptures to the total number of frogs captured in each ten millimeter group. For example, of the 416 frogs captured when in the 25-35 mm group, 24 were taken again (at which time some were in the same size group and some larger), making the rate of recovery about six percent. Thus a picture of the rate of recovery and the reciprocal relationship, the rate of turnover of population, was obtained. By the above method it is assumed that those frogs not captured have disappeared from the study area. This may not be entirely true because during each survey of the area any one individual is subject to capture for a short while only, and if not available at that time it will not be captured, even though it may still be in the area. Therefore, the turnover of animals in all size groups may not be as great as indicated in fig. 7. Then too, the unequal availability of frogs, as shown by the diurnal nature of small frogs and the nocturnal tendencies of large frogs, would require that equivalent collecting be done at all times. This was difficult to attain, especially in the spring and fall when night collecting was often curtailed by low temperatures. Accordingly the recovery rates of the large frogs may be somewhat too low. In view of the above limitations, only a general picture of the rate of turnover is presented here.

The smallest frogs had the lowest rate of recovery (six percent) while the larger frogs had a progressively higher rate, reaching about 42 percent for the 65-75 mm frogs. The recently matured frogs, 75-85 mm in length, were the most stable group, with about one-half of them captured again. Frogs larger than 85 mm showed a slight decline in the rate of recovery, which may indicate that with increasing age they become more vulnerable to disease, predators, or parasites. Only 28 individuals larger than 94 mm were taken in the two seasons, suggesting that a relatively small number of frogs attain large size. In view of the high turnover of practically all groups, it is very doubtful whether more than a few, if any, green frogs live to senility.

The very outstanding difference in the rates of recovery for the two study areas is attributed to the fact that one is primarily a breeding area while the other is not. At Hogback, numerous adults moved into the ponds from outside the study area for reproduction, and later myriads of newly transformed frogs, as well as the adults, dispersed from the ponds. Therefore, the rate of recovery is consistently higher for all size groups at Loch Alpine.

SUMMARY

In two years of collecting near Ann Arbor, Michigan, just northwest of the center of the range of the green frog, 3402 captures were made of 2264 green frogs. All frogs were marked by excision of toes, measured, and released at the place of capture.

Because of the cold climate, green frogs are not available for capture throughout the year. They went into hibernation in the last half of October or the first half of November and did not reappear until the last week of March or the first week of April of the next year. Small individuals were taken first in the spring, and disappeared last in the autumn. This may be the result of the surface-volume relations of the animals and the differences found in the daily period of activity of small and large frogs; the former

were active in daylight, the latter at night. Also it is possible that the early and late captures of small frogs largely correspond with their greater abundance at those parts of the year.

Of all frogs captured, only 26.5 percent were recaptured, indicated a rapid turnover in a large part of the population. About 45 percent of all adults were captured again but only about five percent of those marked as newly transformed frogs were recaptured. Several factors contribute to this large turnover. One is the large number of diverse predators, which take a heavy toll of green frogs in all stages of development. In addition, dispersion, breeding, and adverse weather conditions cause much shifting of frogs.

In any given place the composition of the population varied through the year. During the breeding season, which extends from about mid-May to mid-August, most males were in the ponds, whereas about 80 percent of all adults taken along the stream were females, which were found in very small numbers in the spawning sites. Collections of adults made outside the breeding season showed a ratio of 56 females to 44 males.

In August-September, the late period of metamorphosis, newly transformed frogs constituted nearly all of the population in the breeding ponds. These frogs quickly moved out to locations along the streams where they formed about 95 percent of the population shortly after the peak of the period of transformation. Later in the fall as the season of metamorphosis came to a close, the proportion of subadults steadily declined, primarily because of dispersion and mortality, to about 75 percent in mid-October. In the spring the ratio of subadults to adults continued to decline, reaching about one to one in May. Absence of overwintering tadpoles, as was produced by drought in 1948, caused the percentage of subadults to get as low as ten. The subadult population in both areas was at its lowest in July, just before the late summer season of metamorphosis.

Because of the high rate of turnover of population, as indicated by the low rate of recovery of marked frogs, the proportional method for estimating the size of the population had to be applied with reservation, and the results interpreted to show major trends only. They indicate that the number of green frogs in the study areas was lowest in late July and early August, when the overwintering larvae have metamorphosed and dispersed, and the present season's tadpoles have not yet transformed. In the late summer season of transformation the population of green frogs showed a tremendous upsurge to its highest peak. At Hogback in 1949 the peak of metamorphosis of young hatched earlier in the year, occurred about August 24, when a conservative estimate based on a quadrat study of the breeding ponds indicated about 10,500 newly transformed frogs in an area of 6090 square meters.

REFERENCES

BLANCHARD, F. N. 1929—Rediscovery of *Crinia tasmaniensis*. Austral. Zool. 5:324-328.

——— 1930—The stimulus to the breeding migration of the spotted salamander, *Ambystoma maculatum* (Shaw). Amer. Nat. 64:154-167.

BRECKINRIDGE, W. J. 1944—Reptiles and amphibians of Minnesota. Minneapolis, Univ. Minn Press.

CAHN, A. R. 1937—The turtles of Illinois. Univ. Ill. Bull. 35:1-218.

CUMMINS, H. 1920—The role of voice and coloration in spring migration and sex recognition in frogs. J. Exp. Zool. 30:325-343.

DEARBORN, N. 1932—Food of some predatory fur-bearing animals in Michigan. Univ. Mich. School of Forest. and Cons. Bull. 1.
DOBZHANSKY, T. 1941—Genetics and the origin of species. New York, Columbia Univ. Press.
EMLEN, J. T., A. W. STOKES, AND D. E. DAVIS 1949—Methods for estimating populations of brown rats in urban habitats. Ecology 30:430-442.
ESSIG, E. O. 1942—College entomology. New York, MacMillan.
HOLZAPFEL, R. 1937—The cyclic character of hibernation in frogs. Quart. Rev. Biol. 12:65-84.
KENNEY, J. F. 1939—Mathematics of statistics. Part II. New York, P. Van Nostrand.
LINCOLN, F. C. 1930—Calculating waterfowl abundance on the basis of banding returns. U. S. Dept. Agric. Circ. 118.
LIVEZEY, R. L. AND A. H. WRIGHT 1947—A synoptic key to the salientian eggs of the United States. Amer. Midl. Nat. 37:179-222.
LUTZ, F. E. 1935—Field book of insects. New York, G. P. Putnam's Sons.
LYNN, W. G. AND A. EDELMAN 1936—Crowding and metamorphosis in the tadpoles. Ecology 17:104-109.
MAESTRI, R. S. 1931—Frog industry in Louisiana. La. Dept. Cons. Pamph. No. 2.
MARTOF, B. 1953a—Territoriality in the green frog, *Rana clamitans*. Ecology 34:165-174.
——— 1953b—Home range and movements of the green frog, *Rana clamitans*. Ibid. 34:529-543.
——— 1956—Growth and development of the green frog, *Rana clamitans*. Amer. Midl. Nat. 55:101-117.
MOORE, J. A. 1949—Patterns of evolution in the genus *Rana*. Genetics, Paleontology, and Evolution. Princeton Univ. Press. pp. 315-338.
NOBLE, G. K. 1931—The biology of the Amphibia. New York, McGraw-Hill.
PETERSEN, G. G. J. 1896—The yearly immigration of young plaice into the Limfjord from the German Sea. Rept. Danish Biol. Stat. for 1895, 6:1-48.
POPE, C. H. 1946—Turtles of the United States and Canada. New York, A. A. Knopf.
——— 1947—Amphibians and reptiles of the Chicago area. Chicago, Chicago Nat. Hist. Mus. Press.
RIDER, P. R. 1939—An introduction to modern statistical methods. New York, John Wiley.
SALVOSA, L. R. 1935—Tables for statisticians. Ann Arbor, Edwards Bros.
WALTON, A. C. 1947—Parasites of the Ranidae (Amphibia). Anat. Rec. 99:684-685.
WRIGHT, A. H. 1914—North American Anura; life histories of the Anura of Ithaca, New York. Carn. Inst. Wash. Publ.
WRIGHT, A. H. AND A. A. WRIGHT 1949—Handbook of frogs and toads (Ithaca, Comstock) xii+640 pp.
WRIGHT, S. 1940—Breeding structures of populations in relation to speciation. Amer. Nat. 74:232-248.

Molt of the Short-tailed Shrew, Blarina brevicauda

James S. Findley
University of New Mexico, Albuquerque

J. Knox Jones, Jr.
University of Kansas, Lawrence

Our study of the molt of the short-tailed shrew, *Blarina brevicauda* Say, was based upon 396 museum specimens in the Natural History Museum of the University of Kansas.

Of these 396 specimens 111, or 28 percent, display molt patterns. Thus we are favored with more abundant material than was Hamilton (1940b) who found only 25 molting individuals in more than 1000 specimens, or Townsend (1935) who found one molting shrew in an examination of 742. Where Hamilton concluded that molt in this species does not proceed in any conventional manner, we have been able to detect definite patterns in the adult and post-juvenal molts. The rarity of molting shrews observed by Hamilton led him to think that their molt might be a rapid process. Our data do not support this idea, though they do not necessarily disprove it.

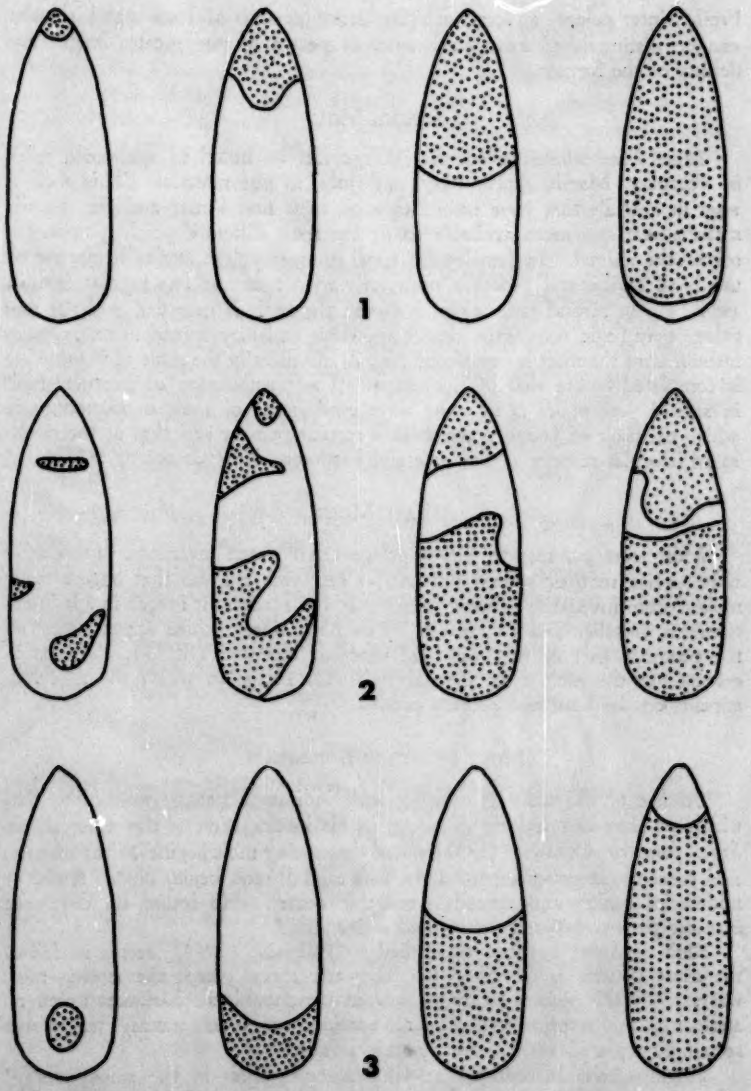
Methods

We examined each specimen for molt lines and after lifting its fur with a needle searched for incoming hair and areas of vascularization of the skin. Areas in molt were plotted upon a mimeographed outline drawing of a shrew, and notations as to age and condition of the pelage involved were added. Age was determined primarily by degree of tooth-wear and fusion of cranial sutures; we followed Pearson (1945) in this respect. When these data were assembled we were able to proceed to the conclusions outlined below.

In order to understand the relationship of molt to the age of the individual, it is necessary to understand first the reproductive cycle of *Blarina*. This subject has been studied by Pearson (1944) upon whose work the following remarks are based. Short-tailed shrews are born in spring and summer and reach sexual maturity the following spring at which time they reproduce. Most females bear one litter (some bear two) and then die in late summer or fall. Few individuals survive a second winter.

Post-juvenal Molt

Newly born *Blarina* are hairless. We have termed the first coat of hair the juvenal pelage. This pelage is characterized by a "fuzzy" appearance seen in the juvenal pelage of many mammals and is retained until the shrew is essentially of adult size. The molt from juvenal pelage to the ensuing pelage, spoken of here as the post-juvenal molt, begins usually in the head region and proceeds caudad, on both dorsal and ventral surfaces of the animal (fig. 1). As often as not the venter molts before the dorsal surface. The kind of new pelage is determined by the time of year in which the shrew is born. Shrews born in the spring and early summer molt from juvenal to summer pelage. Shrews born later in the summer molt from juvenal directly into winter pelage.



Figs. 1-3.—Dorsal view of molt patterns. 1. Post-juvenal molt and spring molt of second year females. Stipple represents incoming pelage. 2. Spring molt of second year males. 3. Fall molt from summer to winter pelage.

Fresh winter pelage, at least in higher latitudes such as Iowa and Nebraska, can be distinguished from fresh summer pelage by the greater length and density of the former.

SPRING MOLT

Molt from winter to summer pelage can be noted in specimens taken in February, March, April, May, and July, in our material. This molt is seen in animals that have passed through their first winter and are sexually mature. In specimens available to us the molt differs depending upon the sex of the animal. In females the fresh summer pelage begins to appear on the head region and proceeds posteriorly in a more or less regular manner (fig. 1). In second year males, however, the molt is irregular, and the new pelage may begin coming in almost anywhere and may spread in an irregular fashion until the molt is completed (fig. 2). Ordinarily the molt of the dorsum is completed before that of the venter. The phenomenon of irregular molt in second year males is in some ways reminiscent of molt in microtines in which the molt of young proceeds in a regular manner and that of the adults in an irregular manner (Applegate and Predmore, 1947; Jameson, 1947).

FALL MOLT

Molt from summer to winter pelage can be seen in second year shrews that survive to their second fall and in first year animals that have already molted from juvenal to summer pelage. In our material it is seen in specimens taken in October and November. The new winter pelage appears first on the posterior part of the body and proceeds cephalad (fig. 3). This is in contrast to the molt from juvenal to winter pelage in which the new hair appears on the head and spreads caudad.

MOLT IN OTHER SHREWS

Studies of the molt of other soricids indicate a pattern resembling that which we have detected for *Blarina*. In his investigation of the water shrew, *Sorex palustris*, Conaway (1952) noted that spring molt begins on the rostrum and proceeds, in general, posteriorly, whereas fall molt begins on the flanks or mid-dorsal region and spreads from this center. He found no difference in molt pattern between young and old animals.

Molt of *Sorex vagrans*, as studied by Dalquest (1944), seems to follow the same pattern as described for the water shrew except that spring molt was said by this worker to begin between the shoulders. Dalquest noted an anomalous mid-summer molt in three specimens in which summer pelage was seemingly replaced with a new summer pelage.

Judging from Hamilton's (1940a) account, molt in the smoky shrew, *Sorex fumeus*, commences on the venter, extends over the shoulders and middle of the back and usually ends on the rump and about the ears.

Jackson (1928), in speaking of the genus *Sorex* in general, stated that spring molt usually begins on the head and moves posteriorly, whereas fall molt is the reverse.

In general, the molt of those soricids that have been studied seems to follow the same pattern, *i.e.*, spring molt progressing posteriorly and autumn molt anteriorly. *Blarina* molts in this fashion with the exception of spring molt in second year males, which seems to proceed in a completely irregular manner. Further study may reveal corresponding irregularity in other shrews. Post-juvenal molt in *Blarina* proceeds from the head posteriorly regardless of season.

MOLT IN MOLES

The mole, *Scalopus*, molts differently from most soricids. Jackson (1915) noted that the new pelage, both in spring and fall, appeared on the venter, then spread over the sides to the rump from which it moved anteriorly. He found that the sequence in *Scapanus* differed from that in *Scalopus;* the molt most frequently beginning on the head and throat and then working posteriorly on the back, the venter molting last. *Condylura* was found to molt somewhat irregularly, though the venter usually is in fresh summer pelage first and the rump last. *Neurotrichus* ordinarily molts first on top of the head, next on the posterior part of the back and anterior part of the venter, and last on the flanks.

Consistent differences between spring and fall molt or between molt of different age groups or sexes were not noted by Jackson.

Clear cut correlation between the molt patterns of soricids and talpids seems to be lacking. Future studies might profitably be designed to determine the biological value, if any, of two or three molt patterns to soricine shrews. In addition it would be interesting to investigate the value of molt patterns as indicators of phylogenetic relationships and at what taxonomic level or levels these patterns might be used as indicators.

REFERENCES

APPLEGATE, V. C., AND H. E. PREDMORE 1947—Age classes and patterns of primeness in a fall collection of muskrat pelts. J. Wildlife Mgt. 11(4):324-330.

CONAWAY, C. H. 1952—Life History of the water shrew (*Sorex palustris navigator*). Amer. Midl. Nat. 48(1):219-248.

DALQUEST, W. W. 1944—The molting of the wandering shrew. J. Mammal. 25(2): 146-148.

HAMILTON, W. J. JR. 1940a—The biology of the smoky shrew (*Sorex fumeus fumeus* Miller). Zoologica 25(4):473-492.

——— 1940b—The molt of Blarina brevicauda. J. Mammal. 21(4):457-458.

JACKSON, H. H. T. 1915—A revision of the American moles. N. Am. Fauna 38:1-100.

——— 1928—A taxonomic review of the American long-tailed shrews. Ibid. 51:1-238.

JAMESON, E. W. JR. 1947—Natural history of the prairie vole (Mammalian genus Microtus). Univ. Kansas Publ., Mus. Nat. Hist. 1(7):125-151.

PEARSON, O. P. 1944—Reproduction in the shrew (*Blarina brevicauda* Say). Amer. J. Anat. 75(1):39-93.

——— 1945—Longevity of the short-tailed shrew. Amer. Mid. Nat. 34(2):531-546.

TOWNSEND, M. T. 1935—Studies on some of the small mammals of central New York. Roosevelt Wild Life Annals 4(1):1-120.

Bones of Mammals From West Virginia Caves

Charles O. Handley, Jr.
U. S. National Museum, Washington, D. C.

Extensive explorations of caves in eastern West Virginia have been conducted by the Charleston Grotto of the National Speleological Society. During the period 1949-1951, R. H. Handley, assisted by R. H. Flack, J. M. Rutherford, I. T. Sanderson, and F. S. Workman, collected bones, mostly mammalian, which are reported in this paper. All material was deposited in the University of Michigan Museum of Paleontology. Specimens were picked up on or near the surface of clay floors of limestone caves and in gravel beds of subterranean streams; no digging, sifting, or washing was attempted. Stratigraphic evidence of the relative geologic ages of the bones was lacking. They possibly are not all the same age. Some may be Recent. At least some, possibly many, are probably late Pleistocene in age, possibly contemporaneous with the material from Cumberland Cave, Maryland, reported by Gidley and Gazin (1938) and Nicholas (1953). Notes on a few Cumberland Cave bones in the U. S. National Museum, not previously reported, are included in this paper. The species composition of the small sample from West Virginia caves is of such interest that further systematic collecting seems desirable.

Collecting Localities

Geographical data are from Davies (1949) unless otherwise noted.

Cabble Cave: Greenbrier County, 1 mi. NW Frankford, 2350 ft., 37° 56′ 20″ N; 80° 23′ 45″ W.

Ramp Hole: Pocahontas County, approx. 4.3 mi. NNE Cass, 3000 ft., 38° 27′ 30″ N; 79° 53′ 56″ W. [This cave is not listed by Davies (1949).]

Organ-Hedrick's Cave: Greenbrier County, 0.4 mi. N Organ Cave P.O., 2200 ft., 37° 43′ 02″ N; 80° 26′ 14″ W.

Patton Cave: Monroe County, 1.4 mi. SE Gap Mills, 2400 ft., 37° 32′ 36″ N; 80° 23′ 56″ W.

Windy Mouth Cave: Greenbrier County, 2 mi. S (by river) Fort Spring, 1750 ft., 37° 43′ 24″ N; 80° 32′ 00″ W.

Species Accounts

Sorex cf. palustris Richardson

Ramp Hole: UMMP 27713.—Tibia-fibula.

Only seven specimens of Recent *Sorex palustris* have been taken in West Virginia. They are from Canadian zone localities in Preston, Tucker, Randolph, and Pendleton counties. Apparently this species is rare in West Virginia. It has not been found in Virginia, but an isolated population inhabits the Great Smoky Mountains in North Carolina and Tennessee.

BLARINA cf. BREVICAUDA Say

RAMP HOLE: UMMP 27712.—Tibia-fibula.

MYOTIS cf. GRISESCENS Howell

CUMBERLAND CAVE: USNM 20881.—Maxillary fragment with P^4-M^3 in place and with alveolus of an additional small premolar preserved. USNM 12427.—Mandible, broken at P_3 and at base of ascending ramus; P_4-M_2 in place. USNM 12429.—Mandible, broken at canine and at base of ascending ramus; P_1-M_3 in place.

ORGAN-HEDRICK'S CAVE: UMMP 27719.—Mandible, complete; I_2-C and P_4-M_3 in place.

PATTON CAVE: UMMP 27723.—Mandible, complete; except ascending ramus broken off at base; P_4-M_3 in place.

WINDY MOUTH CAVE: UMMP 27722.—Mandible, complete, except ascending ramus broken off just above base; P_4-M_1 in place.

Identification of the maxillary fragment required comparison with six genera of bats of eastern North America that possess at least two upper premolars. In order of increasing similarity to the postcanine dentition of *Myotis*, these genera may be distinguished as follows:

Tadarida.—Great development of hypocone in M^1 and M^2, and of protocone in P^4.

Lasiurus.—Reduction of mesostyle in M^1 and M^2 and enlargement of parastyle in M^2 (in *L. borealis*); obliteration to metacone in M^3; displacement of P^1 to lingual side of tooth row.

Corynorhinus.—High, slender cusps and lack of indication of hypocone in M^1 and M^2.

Pipistrellus.—Absence, in M^1 and M^2, of indication of hypocone and protoconule and prominence of ridge connecting protocone and metacone.

Lasionycteris.—Combination of large size and absence, in M^1 and M^2, of protoconule and virtual obliteration of ridge connecting protocone and metacone.

Myotis.—Cusps medium in height; M^1 and M^2 with hypocone prominent, protoconule usually prominent, and ridge connecting protocone and metacone usually present; full third commissure and well developed metacone in M^3. (If all alveoli are preserved, the presence of 3 premolars makes this genus unmistakable.)

Six Recent species of *Myotis* are known to occur in the eastern United States. Three of these may be distinguished by their postcanine maxillary dentitions as follows: *M. keenii.*—Large size, and reduction of the secondary cusps and ridges and prominence of cingulum in M^1 and M^2; *M. subulatus.*—Small size and reduction of secondary cusps and ridges in M^1 and M^2; *M. grisescens.*—Large size and prominence of secondary cusps and ridges, especially the protoconule, and prominence of the cingulum in the hypocone region of M^1 and M^2. I do not believe that *M. austroriparius, M. lucifugus,* and *M. sodalis* can be distinguished from one another by their postcanine dentitions. All are medium in size and possess a fully developed complement of secondary cusps and ridges.

The Cumberland Cave maxilla agrees in every detail with *M. grisescens* but has the teeth slightly more robust. The length of the tooth row, from the anterior edge of P^4 to the posterior margin of M^3, is 4.7 mm in this specimen. For comparison I have taken a similar measurement from each of the six eastern species of *Myotis*. In each instance, the specimen

measured had the longest maxillary tooth row of any USNM specimen listed by Miller and Allen (1928):

M. grisescens (USNM 202024)	4.4 mm
M. keenii (USNM 153640)	4.1 mm
M. austroriparius (USNM 153630)	4.0 mm
M. lucifugus (USNM 207730)	3.9 mm
M. sodalis (USNM 82598)	3.9 mm
M. subulatus (USNM 150275)	3.6 mm

The western *M. velifer* has the teeth somewhat different in structure and even more robust than the Cumberland Cave maxilla (*M. velifer*, USNM 38676, P^4-M^3, 5.0 mm).

The mandibles were recognized as *Myotis* on the basis of characters shown in table 1. I can find no qualitative differences in the mandibular teeth of the large species of *Myotis* of the eastern United States. Some species can be distinguished on the basis of size (see table 2).

The mandibular length is 12.0 mm in UMMP 27719, the only one of the fossil mandibles sufficiently perfect to allow such a measurement. The length

TABLE 1.—Characters for distinguishing low dentitions of genera of eastern North American bats having three mandibular premolars.

	CORYNORHINUS	LASIONYCTERIS	MYOTIS
I_3	crown almost twice as large as crown of I_2	crown similar to crown of I_2 in size	crown almost twice as large as crown of I_2
P_4	single-rooted	double-rooted	double-rooted
P_4	not as high as M_1	as high as M_1	as high as M_1
M_1	lingual side sharply indented between paraconid and metaconid	lingual side relatively straight	lingual side relatively straight
M_1	commissure directly connects hypoconid and entoconid	commissure extends toward entoconid from hypoconid but passes posterior to entoconid rather than directly into it	commissure directly connects hypoconid and entoconid
M_1-M_3	relatively narrow	relatively broad	relatively broad
M_1-M_3	cusps relatively high	cusps relatively low	cusps relatively low
M_1-M_2	in lingual view paraconid about equal to metaconid	in lingual view paraconid smaller and more slender than metaconid	in lingual view paraconid about equal to metaconid

TABLE 2.—Range of measurements of length of mandible and of mandibular tooth row in six species of *Myotis* (from Miller and Allen, 1928).

species	individuals	length of mandible (excluding incisors)	length of mandibular tooth row (C-M_3)
M. grisescens	54	11.0-12.0 mm	6.2-6.6 mm
M. keenii	49	10.2-11.4 mm	6.0-6.6 mm
M. austroriparius	14	10.0-11.0 mm	5.4-6.2 mm
M. lucifugus	60	10.0-11.0 mm	5.4-6.0 mm
M. sodalis	40	10.0-11.2 mm	5.5-6.0 mm
M. subulatus	5	9.4-10.0 mm	5.2-5.6 mm

of the mandibular tooth row is 6.6 mm in this same specimen. The alveolar length of the tooth row is 6.4 mm in the other West Virginia mandibles. The teeth are similarly robust in all of the fossil specimens.

According to Miller and Allen's measurements, some *M. keenii* have tooth rows as long as *M. grisescens*. I have examined their longest (USNM 96957 and 153640), which they measured as 6.6 mm. Either through difference in calipers or technique, I get a measurement of only 6.3 mm on these individuals. Furthermore, the molars are a full tenth of a millimeter narrower in these large *M. keenii* than in the average *M. grisescens* and in the fossils.

Myotis grisescens is known to be a Recent inhabitant of limestone caves from southern Illinois and Indiana to Georgia and northern Florida, and from eastern Tennessee to Missouri and Arkansas. These remains from West Virginia and Maryland caves indicate that *M. grisescens*, or a similar form, occurred farther northeastward in the Appalachian limestone areas in late Pleistocene than *M. grisescens* apparently does at the present time.

In this connection it is of interest to note that there are likewise no Recent Maryland records of *Corynorhinus*, a bat that was abundant in the Cumberland Cave Pleistocene fauna. The Recent form of *Corynorhinus* with geographic range most nearly approximating that of *M. grisescens* has been recorded northward only to south-central West Virginia.

My reluctance to state unequivocally that these remains are *M. grisescens* stems from the fact that neither of the associated Pleistocene forms, *Corynorhinus alleganiensis* and *Eptesicus grandis*, can be distinguished with certainty from Recent species on the basis of dentition, although other cranial features set them well apart.

MYOTIS KEENII Merriam

ORGAN-HEDRICK'S CAVE: UMMP 32593.—Rostrum, broken off at posterior edge of frontals and palate; all alveoli intact; P^4-M^3 in place of both maxillae.

MYOTIS sp.

CUMBERLAND CAVE: USNM 20882.—Mandible, broken at canine and at base of ascending ramus; P_4-M_3 in place.

This is a medium-sized form resembling the Recent species *austroriparius*, *lucifugus*, and *sodalis*, which appear to be indistinguishable on the basis of dentition.

PIPISTRELLUS cf. SUBFLAVUS F. Cuvier

PATTON CAVE: UMMP 32594.—Mandible, broken at canine, and with posterior portion of ascending ramus missing; P_4-M_3 in place.

EPTESICUS cf. GRANDIS Brown

WINDY MOUTH CAVE: UMMP 27721.—Mandible, complete except for tip of angular process, incisors, canine, M_2 and M_3.

Gidley and Gazin (1938) have noted the characters distinguishing the Pleistocene *E. grandis* from the Recent *E. fuscus* Beauvois. In the mandible, the size of the molariform teeth seems most significant. These teeth are consistently more robust (particularly noticeable in width) in *E. grandis* than in the average *E. fuscus*, although extremely large individuals of the latter (e.g., USNM 268512) match *E. grandis* very closely in this respect.

The single specimen of *Eptesicus* in this collection is indistinguishable from *E. grandis*. In view of its association with remains of *Myotis* cf. *grisescens*, apparently of Pleistocene age, this specimen is tentatively identified as *E. grandis*.

MARMOTA MONAX Linnaeus

ORGAN-HEDRICK'S CAVE: UMMP 27705.—Skull with rostum and one zygoma broken; lacking incisors and P^3 from both maxillae.

RAMP HOLE: UMMP 27709—M^2.

PEROMYSCUS sp.

CABBLE CAVE: UMMP 32575—Humerus.

RAMP HOLE: UMMP 27710—Two tibiae. UMMP 27716.—Two fragmentary mandibles, lacking teeth.

ORGAN-HEDRICK'S CAVE: UMMP 27718.—Fragmentary mandible, lacking molars.

PATTON CAVE: UMMP 27724.—Crushed skull.

NEOTOMA MAGISTER Baird.

RAMP HOLE: UMMP 27706.—Fragmentary palate with M^1 in both maxillae. UMMP 27707.—Many bones, skull fragments, and ten mandibles, all immature. UMMP 27716.—Incisors and miscellaneous bones.

The first upper molar of UMMP 27706 has a crown width of 2.6 mm and

a crown length of 3.9 mm. The palatal width of this specimen, measured from the labial surfaces of M^1, is 9.8 mm. UMMP 27706 equals the largest individuals of Recent *Neotoma magister* in size, but cannot be distinguished from them.

MICROTUS sp.?

RAMP HOLE: UMMP 27711.—Innominate.

ERETHIZON DORSATUM Linnaeus

RAMP HOLE: UMMP 27708. Left M^2.

The porcupine is extinct in West Virginia, but probably has occurred there within historic times (Kellogg, 1937). Remains have been found in caves as far south as Tennessee (Kellogg, 1939). The southern limit of the present Appalachian distribution of the porcupine is in Pennsylvania.

PROCYON cf. LOTOR Linnaeus

RAMP HOLE: UMMP 27715. Atlas and canines. UMMP 27716.—Miscellaneous bones and teeth.

MUSTELA cf. RIXOSA Bangs

CABBLE CAVE: UMMP 32574.—Ulna.

In the Recent fauna of West Virginia, *Mustela rixosa* is a widespread, but apparently rare, species. It has been reported only from Mason, Ohio, Randolph, Pocahontas, and Hardy counties.

MYLOHYUS EXORTIVUS Gidley

ORGAN-HEDRICK'S CAVE: UMMP 27728.—Lower incisor, worn. UMMP 27728.—Right M^2, very worn. UMMP 27728.—Left dp^3, unworn. UMMP 27729.—Left mandible, complete except for fragmentation of coronoid and angular processes. P_4-M_3 in place, moderately worn; alveoli of other teeth intact. Fragment of anterior portion of right mandible attached.

Measurements of UMMP 27729, in millimeters: Vertical depth of symphysis (median line) 22.9, length of diastema in front of canine 10.0, length of diastema behind canine 72.4, depth of mandible below M_1 39.7, thickness of mandible below M_1 22.0, alveolar length of canine 17.0, alveolar width of canine 14.0, alveolar length of tooth row (P_2-M_3) 90.5, length of P_4 13.8, width of P_4 15.0, length of M_1 14.5, width of M_1 14.8, length of M_2 16.5, width of M_2 16.5, length of M_3 21.8, width of M_3 14.6.

Measurements of M^2 (UMMP 27728), in millimeters: length 16.2, width 15.2.

Measurements of dp^3 (UMMP 27728), in millimeters: length 12.1, with 10.8.

Reference to Gidley and Gazin's (1938) measurements of the type of *Mylohyus exortivus* shows that the fragments here reported are from slightly

larger individuals. However, proportions are similar, and cusp detail is almost identical. The canine alveolus indicates that the canine was smooth and ovoid in cross-section. The only major difference is in M_3: A small posteroexternal cusp that almost equals the posterointernal cusp in size in UMMP 27729 is not indicated in the type. This probably may be accounted as an individual variation, since divergences of greater magnitude occur in individuals of Recent peccaries and are not regarded as significant.

Mylohyus is rarer than *Platygonus*, the other genus of peccaries found in the Pleistocene deposits of eastern North America. It is known only by a few mandibles and maxillary fragments. No skull has been discovered.

ODOCOILEUS cf. VIRGINIANUS Zimmerman

RAMP HOLE: UMMP 27714.—Four teeth.

ORGAN-HEDRICK'S CAVE: UMMP 27725.—Antler fragment. UMMP 27726.—Scapular fragment.

REFERENCES

DAVIES, W. E. 1949—Caverns of West Virginia. West Virginia Geol. Surv. 19:1-353.

GIDLEY, J. W., AND C. L. GAZIN 1938—The Pleistocene vertebrate fauna from Cumberland Cave, Maryland. Bull. U. S. Nat. Mus. 171:1-99.

KELLOGG, R. 1937—Annotated list of West Virginia mammals. Proc. U. S. Nat. Mus., 84(3022): 443-479.

——— 1939—Annotated list of Tennessee mammals. *Ibid.* 86(3051):245-303.

MILLER, G. S., JR., AND G. M. ALLEN 1928—The American bats of the genera *Myotis* and *Pizonyx*. Bull. U. S. Nat. Mus., 144:1-218.

NICHOLAS, G. 1953—Recent paleontological discoveries from Cumberland Bone Cave. Sci. Monthly 76(5):301-305.

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